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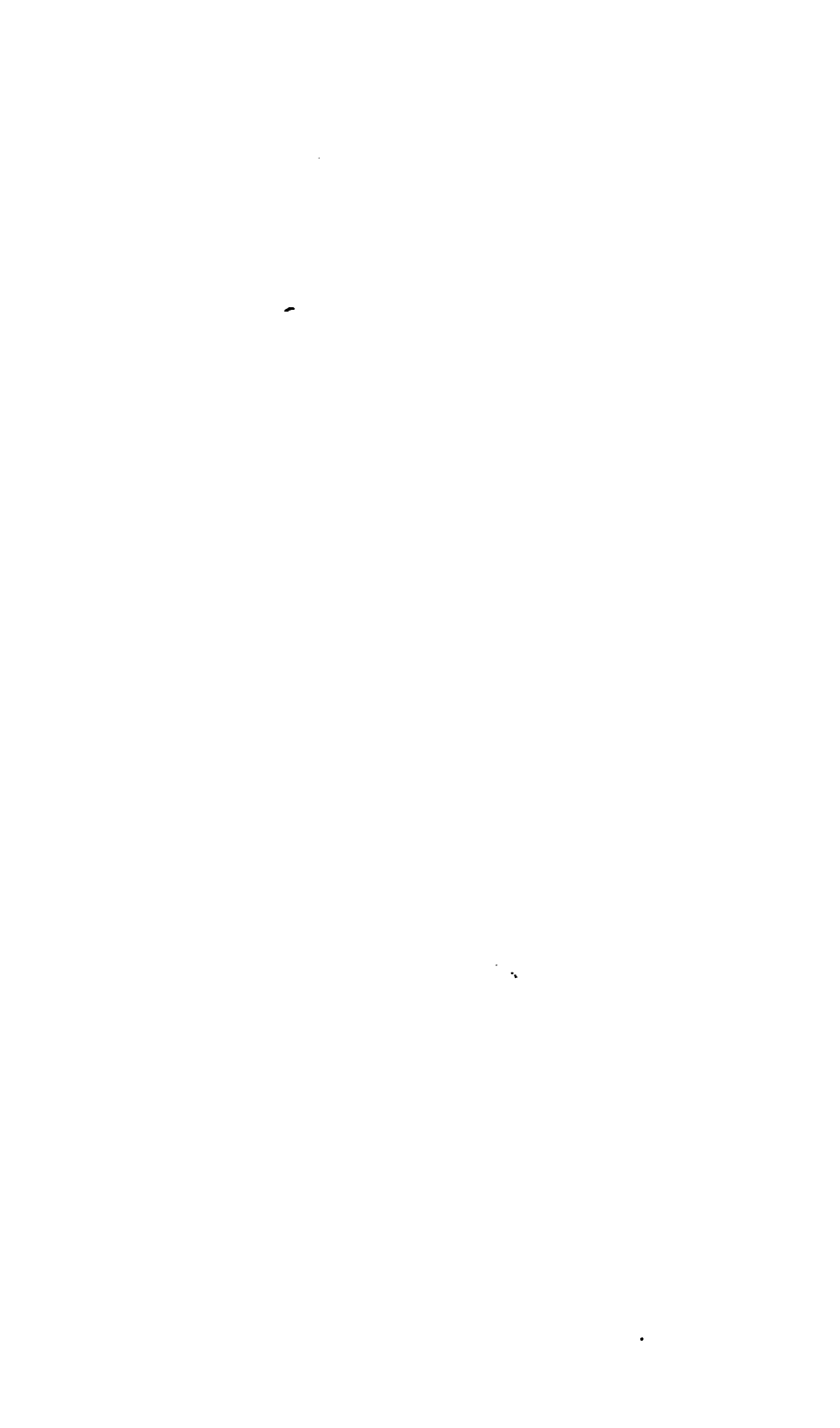
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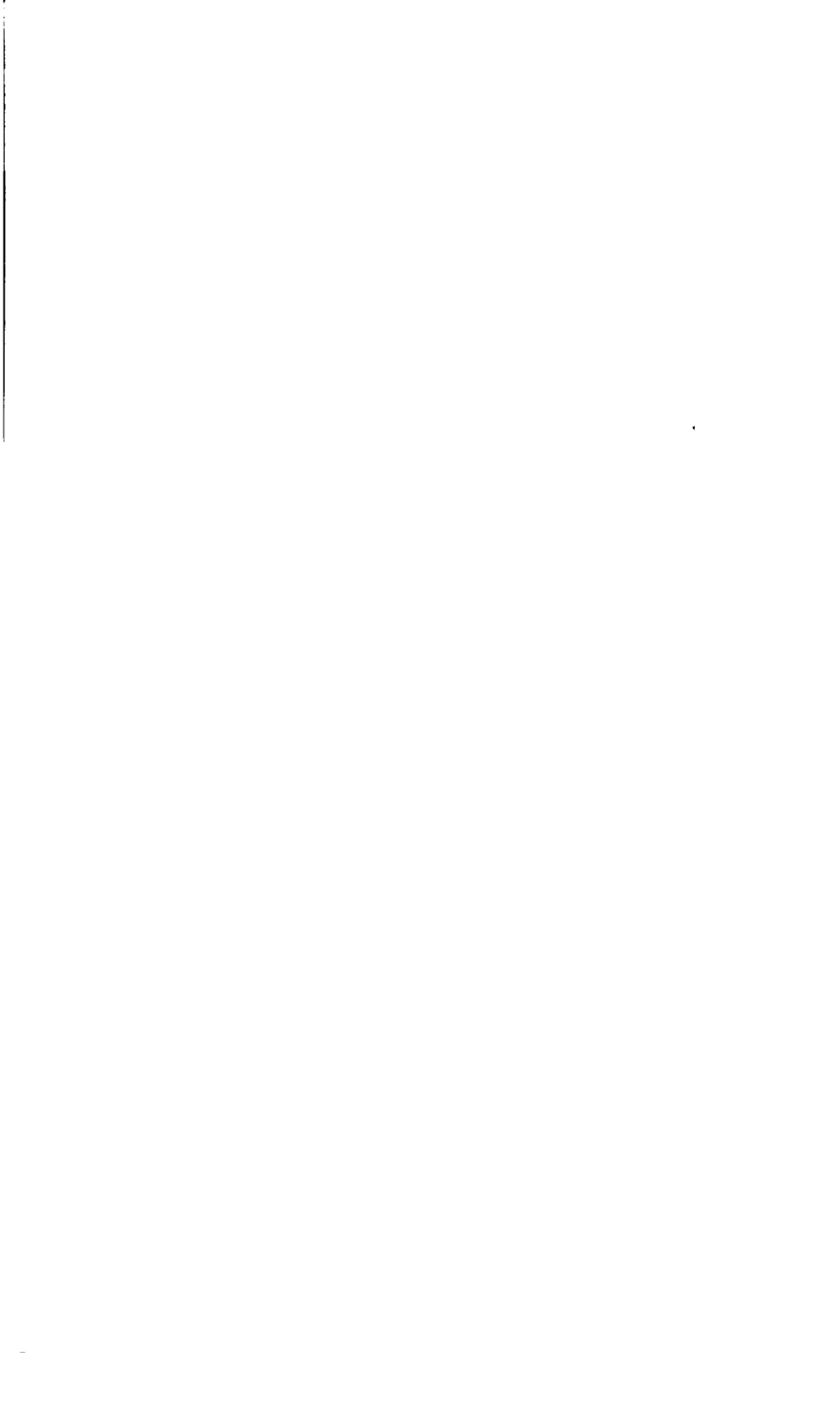
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# SEEDLINGS

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# A CONTRIBUTION TO OUR KNOWLEDGE OF SEEDLINGS

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## BEGONIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 841.

*Fruit and Seed.*—The ovary of the Begoniaceæ is as a rule wholly inferior. That of *Hillebrandia* forms an exception, being free for a short distance at the apex. Most frequently it is three-celled with three wings or angles, rarely one-, two-, four-, or many-celled. The placentas are axile and simple, or consist of two plates, or are branched and project into the cavity of the ovary; in the case of one-celled ovaries they are thick and spongy. The ovules are very numerous, most often covering the whole surface of the placentas and anatropous. The fruit is capsular, dehiscing loculicidally or rarely septicidally; but a few species of *Begonia* have baccate fruits bursting irregularly. Those of *Hillebrandia* dehisce by a large opening between the styles and above the calyx-segments. The capsule of this genus also differs from the prevailing type by being hemispherical and wingless. The mature fruit has the same number of cells as the ovary, and contains very numerous minute seeds of an oblong or cylindrical outline, with a membranous reticulate testa. Endosperm is wanting, or is reduced to a thin layer surrounding the embryo. The latter conforms to the outline of the seed, and has very short cotyledons, with an elongated

radicle, or both may be comparatively stout and of equal length.

*Seedlings*.—Where the seed is minute the seedling must also necessarily be small, but the outline of the cotyledons depends greatly upon the presence or absence of endosperm. The latter has also a great influence upon the size of the seedling both during and after germination. As endosperm is generally absent the seedlings are minute and of slow growth in the early stages. The cotyledons of *Begonia villosa* (fig. 392) are roundly elliptic, entire, shortly petiolate, and close to the ground owing to the shortness of the hypocotyl. The first leaf is cordate, entire, and the second reniform-orbicular and crenate, followed by others which are gradually larger, broader and more or less oblique, the latter character being very prevalent in the Order. The seedlings of *B. parviflora*, *B. boliviensis*, *B. Veitchii*, *B. Pearcei* and other tuberous species agree pretty closely in general characters with the above. The cotyledons of *B. modesta* (fig. 393) are small, oval, shortly petiolate and both directed to one side of the axis. The first leaf is subreniform, entire and oblique, followed by a second that is larger, serrate at the base and very oblique. The third is still more oblique and irregularly dentate. The behaviour of the cotyledons is apparently due to their being connate by their petioles at the base.

***Begonia villosa*, Lindl. (fig. 392).**

*Primary root* slender, with comparatively strong adventitious lateral roots near the upper end at a very early stage.

*Hypocotyl* very short or undeveloped, or suddenly tapered to a blunt point and giving off adventitious roots.

*Cotyledons* very small, rotund, obtuse, very shortly petiolate, glabrous, light green, with a slender midrib but no other discernible venation; lamina 1–1.25 mm. in diameter; petiole dilated and slightly connate at the base, about .5 mm. long above the connate part.

*Stem* herbaceous, erect, terete, slightly pubescent; primary internodes undeveloped.

*Leaves* simple, radical and cauline, alternate, stipulate, petiolate, more or less pilose on both surfaces when young, with jointed hairs, unequal-sided, with alternate, ascending or incurved nerves, all



radiating from near the base, also with the midrib and the principal nerves again giving off alternate ascending smaller branches, bronzy green on the upper surface when unfolding, becoming green with a shining metallic lustre, more or less red beneath; petioles terete, succulent, pale in the young state, becoming reddish, coarsely hairy with jointed hairs; stipules ovate or deltoid, acute or aristate, entire or more or less dentate.

No. 1. Cordate, obtuse, entire, deeply auricled at the base, more or less oblique or unequal-sided.

No. 2. Rotund-cordate, more or less oblique, deeply auricled at the base, five-to seven-nerved, shallowly crenate.

No. 3. Broadly and obliquely cordate, obtuse, deeply auricled at the base, crenate, about eight-nerved—three on one side of midrib and four on the other.

No. 4. Similar, but much larger, more elongated with the principal nerves branched, or sometimes having three nerves on one side and five on the other.

No. 5. Similar to the last but more decidedly oblique, and more elongated at the apex where it becomes much narrower.

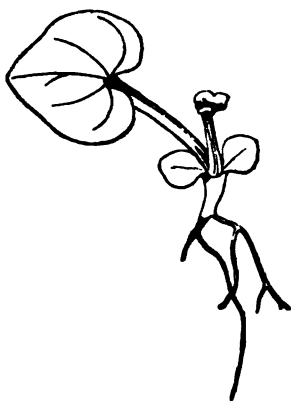


FIG. 392.—*Begonia villosa*,  $\times 4$ .

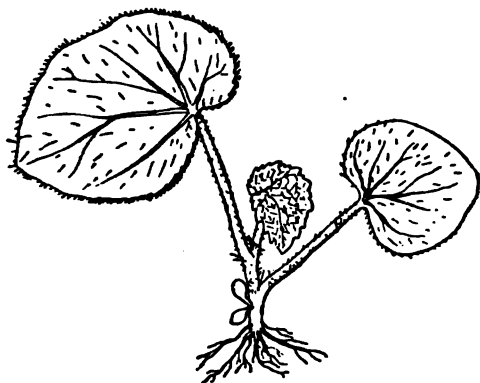


FIG. 393.—*Begonia modesta*. Nat. size.

*Begonia modesta*, Liebm. (fig. 393).

Primary root fibrous, very short.

*Hypocotyl* 3-4 mm. long, 1.5 mm. thick, succulent, terete, glabrous, brownish.

*Cotyledons* directed to one side of the axis, shortly stalked, 3-4 mm. long, 2 mm. wide, obtuse lozenge-shaped or oval, rounded at apex, oblique, entire, with obscure midrib, glabrous, pale green.

*Stem* succulent, terete, pubescent; 1st internode 1-2 mm. long, 1.5 mm. thick; 2nd 3-4 mm. long, 1.5 mm. thick.

*Leaves*.—No. 1. Lamina 1.5 cm. long, 1.75 cm. wide, broadly cordate, obtuse at apex, entire, palmatinerved, membranous, pubescent, bright green above, paler and glabrous below; petiole 1.5-2 cm. long, pubescent.

No. 2. Obliquely cordate, obtuse, obscurely serrate, ciliate and pubescent on both surfaces as well as the petioles.

No. 3. Serrate, and more oblique.

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## CACTEÆ.

Benth. et Hook. *Gen. Pl.* i. 845.

*Fruit and Seed*.—The one-celled ovary is quite inferior. The exterior is smooth or more often covered with scaly bracts or little tufts of bristly hairs or prickles. The placentas are variable in number, but are usually numerous, and parietal, bearing numerous horizontal and anatropous ovules. The fruit is smooth or variously covered with the aborted remains of adnate sepals, and baccate or pulpy when mature. The placentas also form a pulpy mass in which the seeds lie embedded. The latter are oblong or reniform and laterally compressed, or thick and rounded. The testa is crustaceous or bony, of great thickness and dark brown or black, smooth, granulate or covered with small depressions as in some of the *Passifloreæ*. Endosperm is scanty, copious, or almost wanting, and is generally unequally distributed especially in reniform or curved seeds. The embryo varies greatly in different species, being curved, hooked or straight, club-shaped or cylindrical. The cotyledons are of some length, or short, or the embryo may be merely emarginate, making them appear as if they were connate. In other cases they are fleshy, plano-convex or foliaceous. The stout radicle is conical and

short, or cylindrical and elongated. The simplest type of embryo observed is that of *Mamillaria longimamma*. The seed is obovoid, often more or less compressed laterally, and its interior is entirely occupied by the embryo which conforms to it. There is no separation into radicle and cotyledons, but the whole forms an obovoid mass slightly narrowed at the end next the hilum, which may be considered as representing the radicle. The presence of cotyledons is merely indicated by a shallow triangular notch at the apex. From these circumstances and from the behaviour of the seedlings after germination, the greater part of this thick, short and fleshy embryo must be considered as the hypocotyl which has assumed a succulent state, and acts as a storehouse of reserve-material for the use of the young plant. More differentiation is shown by *Echinocactus Wislizeni*. The obliquely oblong or subreniform seed contains a small quantity of subfarinaceous endosperm round one end of which the cotyledons are curved or bent so that the embryo presents an oblong, stout, fleshy body hooked at one end. The embryo of *Cereus Napoleonis* (fig. 395) is very similar to that of *Echinocactus Wislizeni*, but the cotyledons are more bent, and the seed is suborbicular and much compressed with a deep indentation at the hilum. The walls of the testa are very unequally thickened, the greatest thickening taking place round the end of the seed distant from the hilum. Endosperm is wanting, and the curvature of the embryo is brought about by a thickening of the testa and the indentation at the hilum. In *Opuntia Rafinesquii* the seed is reniform or suborbicular, subcompressed, and the embryo is curved round the greater part of the periphery of the seed, enclosing in the curve a quantity of farinaceous endosperm, and greatly resembling what occurs in most of the Caryophyllæ, Phytolaccææ, Chenopodiaceæ, and other allied Orders. The cotyledons are plano-convex and linear. There is more complication in *Opuntia Dillenii* (fig. 399), where the embryo is on the whole curved, but bent or angled three times transversely, enclosing a small quantity of endosperm. The cotyledons are plano-convex and subulate-linear. The large orbicular and compressed seed is very much thickened round the periphery.

*Seedlings.*—The form of the embryo and its parts in the seed have a direct bearing upon the form of the seedling with its cotyledons. We meet with cotyledons of various lengths and shapes, and in some cases they may be considered as absent, or at all events functionless, although morphologically represented. In the seeds of *Mamillaria longimamma* they appear as the edges of a three-cornered cleft, and in the seedling of *M. Goodrichii* they are not more conspicuous and soon become indiscernible. Similar instances are furnished by *Echinocactus viridescens* (fig. 394) and *E. Orcuttii*. The seedling of the first named, eleven months after sowing of the seed, appears as a small obovoid body representing a short fleshy turbinate hypocotyl bearing minute tooth-like cotyledons, above which the short stem is even stouter, leafless, and covered with small spines in tufts arranged in five or six longitudinal rows. Seven months after the sowing of the seeds, *E. Orcuttii* is similar to *E. viridescens*, but smaller.

The cotyledons of *Echinocactus Wislizeni* attain some size in the seed, but after germination they become merged in the succulent stem by the swelling of the latter, so that seven months after sowing they appear as small triangular teeth about 1 mm. long, and of the same breadth, projecting from the sides of the seedling. About four months after sowing, the cotyledons of *Cereus tilophorus* borne by the clavate succulent hypocotyl were 1.25 mm. long, and 2 mm. wide. Those of *Cereus Napoleonis* after three months were 1.5 mm. long, 2.5 mm. wide, triangular and succulent. The hypocotyl in this case is turbinate and very short. The seeds of this species are comparatively small, and so is the seedling during and after germination. Seven months after sowing it is much larger, with the cotyledons about 3 mm. long, and as wide. Strikingly different from all of the above are the seedlings of *Opuntia basilaris* (fig. 398). The hypocotyl is cylindrical or slightly compressed, but much less succulent than any of the above except that of *Cereus tilophorus*. The cotyledons are subulate, bluntly pointed, 1.5–3.5 cm. long, and after a time become disarticulated from the axis. They are also of unequal lengths. Abnormal forms

occur, having only one cotyledon, while one of them in other cases is bifid. Other species of *Opuntia* observed not only differ from most members of the Order, but also remarkably from the last species mentioned. The hypocotyl of *O. Labouretiana* is subterranean, and the cotyledons are ovate, obtuse, fleshy, and very unequal, the larger one being about 2 cm. long, and 1.5 cm. wide, and the shorter one 1.5 cm. long, and 1 cm. wide. They are deep green and persistent. Those of *O. occidentalis* (fig. 400) are similar, but smaller in every way. In both of these species true leaves occur—a very unusual occurrence in the Order. They are small, subulate, succulent, seated on little elevations of the stem, surrounded by fascicles of spines and arranged in ascending spiral rows; but as they become yellow and fall away early, they are comparatively functionless. Large foliaceous and persistent leaves occur in the species of *Pereskia*. The cotyledons of *Phyllocactus stenopetalus* (fig. 397) are similar to those of *Opuntia occidentalis* and *O. Labouretiana*; but are very much larger. The hypocotyl is terete and unusually elongated, while the stem is much flattened and leafless, with fascicles of short bristles at the nodes along the edges. The genus *Nopalea* is closely allied to *Opuntia*, and *N. dejecta* resembles *Opuntia basilaris* in its hypocotyl, which is cylindrical and 1.6 cm. long; but the large ovate fleshy cotyledons, the conical fleshy stem, and the small caducous leaves resemble those of *Opuntia Labouretiana*.

***Mamillaria Goodrichii*, Scheer.**

*Primary root* small, tapering, with very few lateral rootlets, but numerous root-hairs.

*Hypocotyl* succulent, ovoid at first and afterwards globose, glabrous, pale transparent green, suffused with pale purple, 2.5 mm. long, 3.75 mm. broad.

*Cotyledons* represented by the margins of a cleft at the apex of the hypocotyl, and soon becoming indiscernible.

*Stem* succulent, developing very slowly and crowned in the seedling stage with tufts of short slender spines; spines pink, ultimately white, pubescent, about equal in size.

*Leaves* none or represented by the above-mentioned spines or bristles.

**Echinocactus viridescens, Nutt. (fig. 894).**

*Primary root* short, tapering, with a few fleshy lateral rootlets, and abundance of root-hairs.



FIG. 894.  
*Echinocactus*  
*viridescens.*  
Nat. size.

*Hypocotyl* succulent, short, erect, but distinctly thinner than the stem, pale transparent green, suffused with purple, and mottled with pale markings, 4.5 mm. long, 6 mm. thick.

*Cotyledons* reduced to minute, scarcely elevated green teeth.

*Stem* succulent, erect, oblong or globose in the seedling stage, glabrous, shining, coloured like the hypocotyl, slightly five- or six-angled and furnished with tufts of spines in as many rows; spines unequal with usually the central one much longer, red or pink when young, ultimately white, pubescent and seated on the top of little elevations of the stem in a cushion of short cottony or woolly hairs.

*Leaves* none.

The seedling of *Echinocactus Orcuttii*, *Engelm.*, closely resembles that of the last species.

**Cereus Napoleonis, Hook. (fig. 895).**

*Fruit* baccate, scaly, one-celled, many-seeded; pericarp pulpy.

*Seed* irregularly suborbicular, and angled, compressed, glabrous, black, minutely tuberculated all over, but most conspicuously along about half its margin which is bordered with a ring of thickened tissue; testa much thickened, crustaceous or almost bony; tegmen much thinner, membranous, pale-coloured, finely reticulated; hilum very large and conspicuous, forming a deep bordered pit at the base of the seed; micropyle contiguous, inconspicuous, and appearing lateral owing to the size of the hilum.

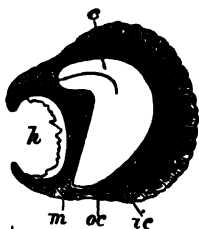


FIG. 895.  
*Cereus Napoleonis.*  
Longitudinal section of  
seed,  $\times 9$ : *h*, hilum;  
*m*, micropyle; *oc*,  
testa; *tc*, tegmen;  
*c*, cotyledon.

*Endosperm* wanting.

*Embryo* bent or hooked, or hammer-like, occupying the whole interior of the seed, fleshy, colourless; cotyledons short, oblong, obtuse, entire, semiterete, fleshy, placed with their edges to the compressed sides of the seeds and consequently in the narrow way of the latter, bent at right angles to the radicle; radicle about as long as the cotyledons, oblong, suddenly tapered

to a turbinate obtuse point, fleshy, lying close to the micropyle where the wall of the seed is thinner.

### Seedling.

*Hypocotyl* succulent, turbinate or obconical, glabrous, pale transparent green, suffused with pale purple, and mottled with pale grey markings, 8 mm. above ground, tapering to a long more slender base, altogether 1 cm. long.

*Cotyledons* triangular, obtuse, succulent, horizontal, tapering into the stem with a convex surface both above and below, coloured like the stem, and projecting about 1.5 mm. from it, 2.5 mm. wide at the base, persistent.

*Stem* succulent, obtusely five-angled, glabrous, coloured like the hypocotyl, with rows of slender, pink or white, minutely pubescent bristles on the angles.

*Leaves* none.

### *Cereus Emoryi*, Engelm. (fig. 896).

*Primary root* tapering, stout with lateral rootlets closely clinging to the soil.

*Hypocotyl* turbinate, very stout and fleshy, glabrous, purple, mottled with white, about 5 mm. long.

*Cotyledons* short, very fleshy, perfoliate, amalgamated with the hypocotyl and the stem, with spreading or slightly decurved, triangular, acute points, convex on both surfaces and coloured like the hypocotyl; free points about 8 mm. long, and as wide or wider at the base.

*Stem* fleshy, or succulent, erect in seedling stage, oblong-ovoid, glabrous and glossy, green, slightly suffused with purple, covered with stellate tufts of white, or pale brownish bristles in seven to eight longitudinal rows; about 1.5-2 mm. between each tuft, and 1.5-3 mm. between the rows.

*Leaves* none.

### *Cereus tilophorus*, Pfeiff.

*Hypocotyl* succulent, clavate, pale purple mottled with pale grey, glabrous, about 7 mm. above ground.

*Cotyledons* succulent, triangular, obtuse, horizontal, 1.25 mm. long, 2 mm. wide at the base, coloured like the hypocotyl, persistent.

*Stem* succulent, erect, glabrous, coloured like the hypocotyl, and



FIG. 896.  
*Cereus Emoryi*.  
Nat. size.

furnished with tufts of slender, white, glabrous bristles seated on the top of little woolly-capped elevations, in five or six rows.

*Leaves* none.

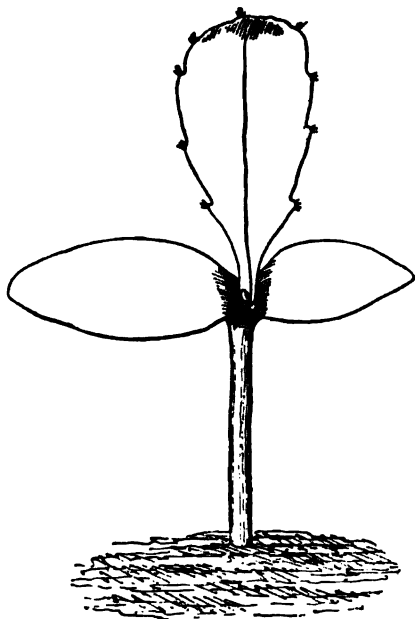


FIG. 897.—*Phyllocactus stenopetalus*.  
Nat. size.

***Phyllocactus stenopetalus*, Salm-Dyck (fig. 897).**

*Hypocotyl* stout, erect, terete, glabrous, 1·8–2·4 cm. long, green.

*Cotyledons* ovate or oblong, fleshy, acute, entire, sessile, connate at the base, very unequal, glabrous, green, without any venation.

*Stem* fleshy or succulent, erect, much flattened, leafless, with small tufts of hairs or bristles at the nodes, otherwise glabrous, crenate or notched along the edges.

***Opuntia Rafinesquii*, Engelm.**

*Fruit* a fleshy pulpy berry, many-seeded.

*Seed* subrotund or oblate, much flattened laterally; testa hard, bony, rugose; hilum rather conspicuous.

*Endosperm* scanty, farinaceous, surrounded by the embryo and white.

*Embryo* curved, lying on the outside of the endosperm; cotyledons linear, curved at the end, obtuse, entire, lying the narrow way of the seed with their faces to the axis; radicle slightly longer than the cotyledons, incumbent, terete, obtuse.

***Opuntia basilaris*, Engelm. et Big. (fig. 898).**

*Primary root* short, succulent, woolly, tapering downwards, with a few short, lateral, fibrous rootlets.

*Hypocotyl* succulent, 1–2 cm. long, 3–4 mm. thick, slightly compressed, glabrous, of a dull bronze colour, reddish later.

*Cotyledons* sessile, 1·5–3·5 cm. long, about 4 mm. thick near the base, subulate, similar to the hypocotyl in outer appearance,



showing no pulvinus till after the suberect position is changed to a horizontal one, not very persistent.

One of the two cotyledons is sometimes bifid, and occasionally only one is present.

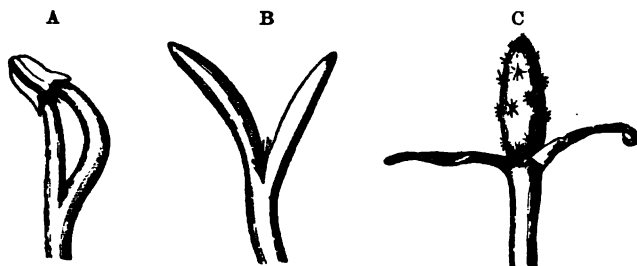


FIG. 398.—*Opuntia basilaris*.

A and B, stages in germination. C, seedling. All nat. size.

*Stem* conical, succulent, about 5 mm. thick at first, green, with acicular spines projecting in a substellate manner from slightly tomentose protuberances arranged spirally around the young stem.

*Opuntia Dillenii*, Haw. (fig. 399).

*Fruit* baccate, pyriform, tuberculate, one-celled, many-seeded, with the seeds embedded in pulp.

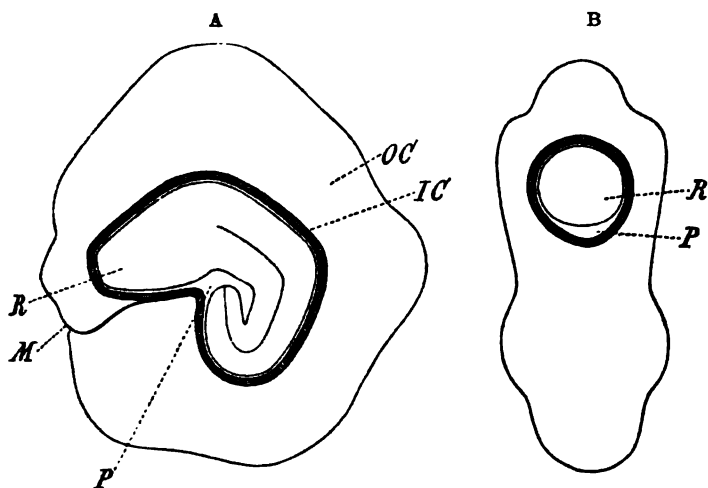


FIG. 399.—*Opuntia Dillenii*. A, longitudinal section of seed,  $\times 9$ : R, radicle; M, micropyle; P, endosperm; OC, testa; IC, tegmen. B, transverse section of seed near base,  $\times 9$ : R, radicle; P, endosperm.

*Seed* large, orbicular, laterally compressed, pale brown or whitish; testa thickened, hardened, almost bony, forming a strong marginal ridge all round the seed except at the hilum and micropyle, and also a submarginal ridge on each face; tegmen black, crustaceous, closely adhering to the testa, brownish on its inner face and finely reticulate; micropyle and hilum contiguous, basal.

*Endosperm* in the mature seed scanty, white, subfarinaceous, generally forming a thin layer surrounding the embryo, but thickest in the angle formed by the curve of the latter and leaving an evident trace there when it has all been absorbed elsewhere.

*Embryo* curved or hooked, large, assuming this shape from the enormous thickening of the testa, almost colourless when dry, white when moist; cotyledons subulate, linear, obtuse, entire, plano-convex or semiterete, considerably narrowed to the sharply incurved tip, incumbent; radicle short, oblong, obtuse, bent nearly at right angles to the cotyledons, lying close to the micropyle where the testa is thinnest.

***Opuntia occidentalis*, Engelm. (fig. 400).**

*Hypocotyl* subterranean, stout, tapering downwards, pale purple.



FIG. 400.—*Opuntia occidentalis*.  
Nat. size.

*Cotyledons* succulent, unequal, ovate, obtuse or tipped with a cartilaginous point, nearly flat above, convex on the back; glabrous, shining, deep green, mottled with minute pale grey markings; larger one 1·85 cm. long, 9 mm. wide; shorter one 1·4 cm. long, 7·5 mm. wide, persistent.

*Stem* succulent, erect, glabrous, deep green, shining, leafy, ultimately naked or without leaves, and furnished with tufts of long, slender, glabrous, bristly, white spines, springing from woolly cushions, in numerous rows; internodes very short, each about 2 mm. long.

*Leaves* small, numerous, succulent, forming longitudinal spiral rows on the stem, subulate, or narrowly conical, acute, glabrous, dull green, seated on little elevations of the stem, 1·5–2·25 mm. long, ·5–·75 mm. wide, deciduous.

The seedling of *Opuntia Labouretiana*, ? *Auct.*, closely resembles the last, but has its unequal cotyledons wider, and the young stem clavate.

## FICOIDEÆ.

Benth. et Hook. *Gen. Pl.* i. 851.

*Fruit and Seed.*—The ovary is inferior in Mesembryanthemum and Tetragonia, but in other genera it is usually surrounded by the persistent calyx. The carpels vary from four to twenty, and unite so as to form an ovary of as many cells. The ovules are solitary and basal, or suspended from the top of the cell, or they are numerous and arranged on placentas attached to the inner angles of the cells, and amphitropous. The fruit is capsular, dehiscing longitudinally, or transversely at the apex. In comparatively few cases it is an achene, or drupe, or consists of several lignified pieces, while in other cases it breaks up into cocci or utriculi. The seeds are solitary or indefinite, reniform, globose, or obovoid, with a membranous or crustaceous testa. Endosperm is present in greater or less quantity and in most cases is of a farinaceous character. The embryo is most often more or less curved or subannular, peripheral, and terete, with linear, plano-convex, incumbent cotyledons and a terete radicle.

There are several exceptional forms in the Order, the most marked of which is Adenogramma, consisting of seven species of South African plants having a one-celled, one-ovuled ovary, and a fleshy endosperm.

The ovary of Gisekia is apocarpous, and consists of five carpels, while in Trianthema and sometimes Galenia there is only one carpel. A type of the Order is represented by Tetragonia expansa (fig. 403), having somewhat flask-shaped seeds suspended one from the apex of each cell by a slender funicle. The embryo is terete, and surrounds nearly the whole of the periphery of the endosperm, with the radicle occupying the neck of the seed. The fruit is many-celled, woody, and indehiscent, with generally a seed in each cell. The mode of germination is shown in fig. 404: the embryo pushes its way through the apex of the fruit, where the walls are very thin in places. In order to make their exit through these narrow openings, it is necessary that the cotyledons should be linear.

Owing to the number of seeds and embryos in each fruit there must be a great competition amongst the seedlings in a state of nature, since there is no means of dissemination, as in fruits which dehisce.

*Seedlings*.—In general characters there seems to be very little variation amongst the cotyledons of this Order, although they vary slightly in detail. Those of *Tetragonia expansa*, above-mentioned, are the longest and narrowest. Amongst the species of *Mesembryanthemum* they are broadly or narrowly oblong, rounded at the apex, sessile and connate, or perfoliate at the base, and so succulent that no venation is discernible, except sometimes a faint indication of a midrib.

*Mesembryanthemum tricolorum* (fig. 401) presents a short and comparatively broad type. The leaves are linear or semiterete, and succulent with the first pair developed close to the cotyledons, or if the seedlings are crowded at some distance from them. The leaves of *M. capitatum* are also semiterete. The cotyledons of *M. serratum* and *M. echinatum* (fig. 402) closely conform to those of *M. tricolorum*; and the primary leaves are subulate, semiterete or obtusely trigonous and succulent.

A modification of the above type is exhibited in the cotyledons of *M. cordifolium*, which are broadly oblong, foliaceous, flat but succulent, minutely wrinkled or areolated, 1.2–1.5 cm. long, and 7–9 mm. wide. It is a significant fact that the leaves are also flat and ovate, or subcordate, from the first pair onwards. The cotyledons are however slightly connate at the base. A type with narrow cotyledons occurs in *M. pinnatifidum* where they are linear-oblong. The primary leaves are radical, but the stem ultimately becomes elongated and procumbent or trailing, with cauline leaves. The first pair are spatulate and entire, followed by others which are sinuately pinnatifid with rounded alternate segments.

***Mesembryanthemum tricolorum*, Haw. (fig. 401).**

*Primary root* short, tapering, giving off a few lateral fibrils; upper part succulent.

*Hypocotyl* succulent, stout, tapering from the cotyledons downward, variable in length and subsequently giving off a few short rootlets.

*Cotyledons* connate at the base or perfoliate, sessile, oblong, obtuse, glabrous, pale green, succulent, 5-8.5 mm. long.

*Stem* erect, terete, ultimately decumbent, thickened upwards from the pair of leaves below to the pair above, deep red, soft, succulent and watery; 1st internode 8-10 mm. long.

*Leaves* cauline, opposite, decussate, exstipulate, sessile, connate



FIG. 401.

*Mesembryanthemum tricolorum.*  
Nat. size.



FIG. 402.

*Mesembryanthemum echinatum.*  
Nat. size.

at the base or perfoliate, linear, obtuse, watery, and succulent, glabrous, covered with longitudinal glandular lines which exude a liquid, at least when young, pale green or suffused with red, and more or less crystalline in appearance.

First pair distant from the cotyledons, possibly owing to crowding in the seed-bed.

Second and third pairs crowded when young.

*Mesembryanthemum echinatum*, Ait. (fig. 402).

*Primary root* slender, tapering, with very slender lateral fibrils.

*Hypocotyl* subterranean and short, indistinguishably merging into the root.

*Cotyledons* short, rounded at the end, flattened horizontally, perfoliate, succulent, glabrous.

*Leaves* simple, entire, radical, opposite, exstipulate, sessile, glabrous, subulate, acute, or subaristate in the young condition, deeply convex on the back and smooth or slightly elevated into rounded and shallow prominences with corresponding depressions between them, flattened on the upper surface and slightly uneven, bright green and shining on both surfaces.

First pair 1·65–2 cm. long.

Second pair 4–6·5 cm. long.

Third pair 4–6 cm. long.

*Mesembryanthemum pinnatifidum*, L. fl.

Primary root fleshy, tapering and giving off lateral rootlets, annual.

*Hypocotyl* succulent, stout, red, glabrous, about 8 mm. long, 2 mm. thick.

*Cotyledons* linear-oblong, obtuse, fleshy, flattened above, convex beneath, connate and perfoliate at the base, green often suffused with red, 6 mm. long, 2 mm. wide.

*Stem* annual, ultimately elongated, procumbent.

*Leaves* simple, radical and cauline, opposite, exstipulate,

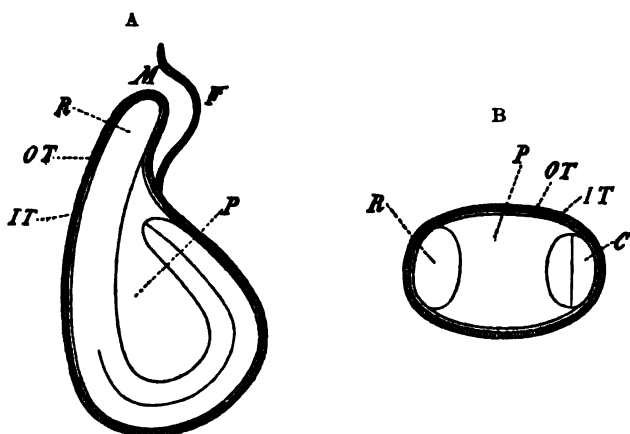


FIG. 408.—*Tetragonia expansa*,  $\times 14$ . A, longitudinal section of seed: P, endosperm; F, funicle; M, micropyle; R, radicle; OT, testa; IT, tegmen. B, transverse section of seed: C, cotyledons.

petiolate, glabrous, succulent, crowded with glands which cover all parts of the plant, like crystalline papillæ; petioles stout, succulent, channelled above, convex beneath, much dilated at the base and amplexicaul.

First pair spatulate, obtuse, entire.

Second pair sometimes similar or somewhat broader, but more frequently oblong, obtuse, shallowly and repandly lobed; lobes rounded, alternate.

Third and fourth pairs oblong, obtuse, pinnatifid; lobes rounded or oblong, entire, alternate, largest at the upper half of the leaf, and smallest towards the base.

*Tetragonia expansa*, Ait. (fig. 403).

*Ovary* inferior, of many carpels, many-celled, with one pendulous, campylotropous ovule in each cell ; micropyle superior.

*Fruit* a nut, more or less compressed on two sides when dry,

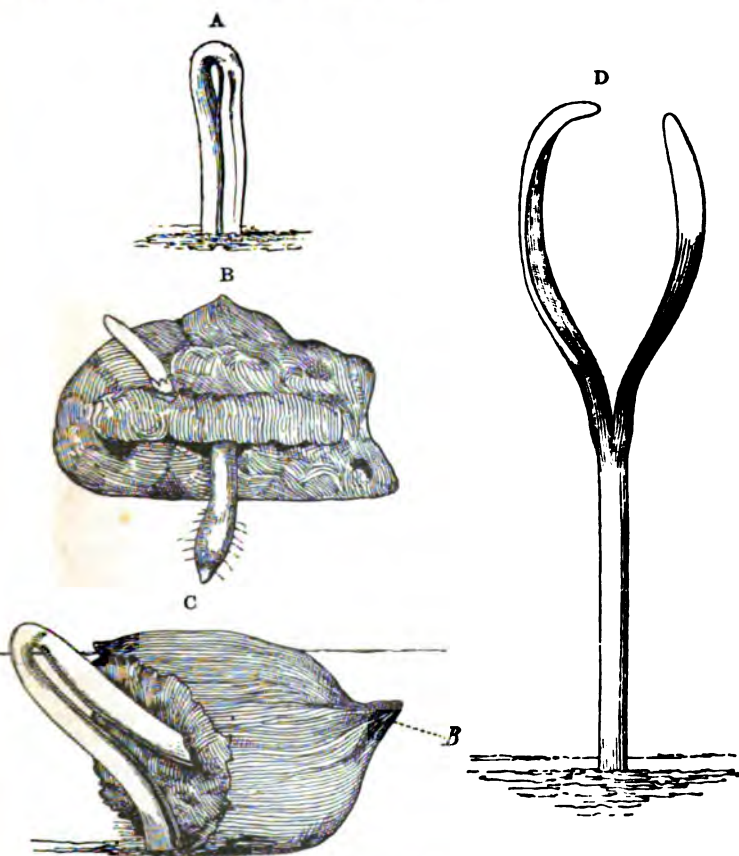


FIG. 404.—*Tetragonia expansa*,  $\times 4$  A, seedling from a seed that had been removed from the fruit before sowing. B, fruit soaked in water before sowing. C, another, soaked in water before sowing. D, seedling after it has left the fruit.

variously angled, free at the apex, furnished above the middle with four to five horns, with the three- to five-lobed calyx a little higher up, glabrous or nearly so, but somewhat scabrous, hard and woody when dry, many-celled with one seed in each cell, indehiscent.

*Seed* suspended from the top of the cell by a long slender funicle,

curved and somewhat flask-shaped, owing to the greatly elongated part containing the radicle and micropyle, conforming to the interior of the cell, pale brown, glabrous; testa and tegmen both thin and membranous; hilum at the notch on one side formed by the curvature of the seed; micropyle at a much higher level, being carried up by the elongation of the part containing the radicle.

*Endosperm* central, of moderate quantity, farinaceous or mealy, pure white.

*Embryo* large, curved, peripheral, and nearly entirely surrounding the endosperm, almost colourless; cotyledons incumbent, linear, obtuse, entire, plano-convex, lying in the narrow plane of the seed with their backs to the axis of the fruit; radicle terete, obtuse, somewhat longer than the cotyledons, and nearer to the axis of the fruit.

(A) Seedling appearing above ground from a seed taken out of the fruit before sowing.

(B) Fruit that had been soaked in water before sowing. It is many-celled and many-seeded, and the radicles of two germinating embryos are shown. The upper end of the fruit is shown in the sketch.

(C) From another fruit showing upper end, two sides, and the turbinate base, B. The embryo is further advanced in this case. (The fruit had been soaked.)

(D) Whether seed or fruits are sown, the embryo rises clear out of either if properly covered with soil. At this stage (four days after germination) the hypocotyl is glabrous, colourless or reddish at the top, and the cotyledons are linear, obtuse, entire, glabrous and slightly narrowed to the base where they are stained with red.

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## UMBELLIFERÆ.

Benth. et Hook. *Gen. Pl.* i. 859.

*Fruit and Seed.*—The ovary is inferior and consists of two carpels united so as to form two cells; it is rarely one-celled by abortion. The ovules are solitary in each cell, suspended from the top, and anatropous. The fruit is a cremocarp, ultimately splitting into equal portions called mericarps, each furnished with five primary ridges and sometimes four



secondary ones, with the ridges at the commissure slender or less often developed into wings, sometimes separating from an axial carpophore, and each one-seeded and indehiscent. The walls of the fruit are always dry, and the outer or exocarp is membranous, crustaceous, or thickened and corky. The seed conforms to the cavity of the cell, to the inner wall of which it is adnate, and is flattened, or longitudinally furrowed or concave along the ventral face, or is altogether free. The testa is thinly membranous; and the interior is occupied with a copious cartilaginous endosperm. The embryo is small, close to the hilum, often minute, and ovoid, or larger with ovate or linear cotyledons which may be equal or unequal. The radicle also varies somewhat in length, but is usually short and always superior.

A few exceptional cases occur in the Order, as for instance in *Actinotus* and *Petagnia* where the ovary is one-celled, and one-ovuled by abortion, and in *Lagoëcia* which is monocarpellary. In various species three carpels occasionally appear, while in others, one of the two carpels is imperfect or becomes aborted. The exocarp of *Apleura* is fleshy, while the endocarp is lignified. The embryo being very small is not of much use in classifying the species of this large Order. The fruits and seeds themselves are however very variable, and although they never attain any great size relatively, their characters are constant, and in systematic classification the form and the flattening, whether dorsal or lateral, the ridges both primary and secondary, and the number of oil cavities or vittæ in the interstices are of the greatest importance for arranging the species into tribes and genera. The tribes again are grouped into three primary series according to the characters of the inflorescence, the ridges and the vittæ.

The fruits appear to fall into five groups according to the form of the mericarps, and the seeds they contain. In all of these groups the cotyledons have their backs to the axis, a few only their edges, but these may be considered as exceptions to the general rule, and will be mentioned by themselves. The groups merely represent types with strongly marked characteristics. The first contains those fruits where the mericarps are more or less distinctly pentagonal. A good type of

this kind is furnished by *Ptychotis Ajowan* (fig. 411). The fruit as a whole is ovate and laterally compressed; and the embryo is shortly linear, and less than half the length of the endosperm. *Bupleurum ranunculoides* differs chiefly by its oblong fruits and minute obovoid embryo. The primary ridges are acute and much more strongly marked in *B. fruticosum* than in its congener. The fruit of *Fœniculum vulgare* has strong blunt ridges and the commissure is by far the broadest face of the mericarp. The embryo is slender and more elongated than in *Bupleurum*.

The second group is characterised by the triangular outline of the mericarp in transverse section. This is represented by *Eryngium giganteum*. The fruit as a whole is ovoid, subquadrangular, with four double rows of ascending stiffish scales, and covered with others that are adpressed in the intervening spaces.

The third group is well characterised by fruits much compressed dorsally. The three dorsal ridges of the mericarps are slender; but those at the edges of the commissure are considerably drawn out, yet united with one another so as to form a single wing encompassing the lateral margins of the fruit. They ultimately separate from one another when the mature cremocarp splits into its component halves. The embryo is minute. The mericarps of *Peucedanum Schottii* are oblong-oval or elliptical and plano-convex, with a narrow wing. Those of *Ferula communis* are larger and even more decidedly flattened, seeing that they are scarcely convex on the back, and the marginal wing is much broader. Here may be placed *Dorema*, *Lefeburia*, *Heracleum*, *Polytænia*, *Opopanax* and others. A slight modification is exhibited by *Levisticum*, *Angelica*, *Archangelica* and others, in which the lateral ridges are not united, but form a double wing encompassing the mericarps. In some genera all the five ridges of each mericarp are drawn out, forming wings as in *Pleurospermum* and some others. The fruit of *Pleurospermum* is however more convex or but little compressed dorsally.

In the fourth group the lateral edges of the mericarps are more or less contracted or incurved, making them fluted, or furrowed along the ventral or commissural face. The seeds

also conform closely to this peculiar outline, as is best seen in transverse section. This type is well illustrated by *Scandix Pecten-Veneris*. The fruit is prolonged at the apex into a long, slender, tapering or subtapering beak; the portion containing the seed is linear-oblong. The embryo is slender and rather elongated. *Myrrhis odorata* differs in having a larger fruit with a shorter beak, the primary ridges prominent and acute; and the embryo seems to be situated near one edge of the seed. The dorsal and lateral ridges of *Cuminum Cyminum* are the most prominent, while the intermediate ones are small, making the mericarps triangular in transverse outline. The ventral face of mericarp and seed are but slightly grooved; and the embryo is axial. On the other hand, the mericarps of *Caucalis nodosa* are much infolded at the sides and deeply grooved on the ventral face. The fruits are chiefly remarkable for their dimorphic character. Those on the circumference of the umbel have the outer or most exposed mericarp furnished with a double row of spreading, curved, and hooked bristles on each of the secondary ridges, while the corresponding more protected centripetal carpel as well as all the rest of the fruits are only muricate on the secondary ridges.

The fifth group includes those fruits which are involute not merely at the sides but also at either end, forming a deep cavity on the ventral aspect in each of the two mericarps. This is strongly suggestive of what occurs in *Galium* amongst the *Rubiaceæ*. The fruit is didymous, and each mericarp is somewhat globular in *Smyrniurn perfoliatum*. The embryo is axial as usual, but owing to its shortness and to the curvature of the seed it is horizontal with its radicle close to the sub-lateral micropyle. It is straight or slightly curved and of comparatively large size; and during germination or growth previous to germination it must become considerably curved in order to accommodate itself to the peculiar shape of the seed. A very exceptional case occurs in *Trachymene pilosa* (fig. 406). The fruit is laterally very much compressed, with the commissure of the mericarps correspondingly narrow. The most striking feature of the seeds, which conform to the shape of the mericarps, is that the embryo has the edges

of its cotyledons turned towards the axis, in order to find accommodation during the process of germination in the laterally flattened fruits. The embryo in the transverse section of the mericarp appears to be eccentric, but this phenomenon is due to the mericarp being suddenly narrowed on the dorsal edge near the apex. The fruit of *Chærophyllum aureum* is narrowly oblong, and dorsally compressed, with the commissural face much the broadest. Contrary to what we should expect, the cotyledons have their edges instead of their backs to the axis, notwithstanding the fact that they lie in the narrowest plane of the seed. Owing to the seed being deeply grooved along the ventral face, the species belongs naturally to the fourth group of which it is an anomalous member. In like manner *Carum Carvi* (fig. 410) should belong to the first group, seeing that its mericarps are almost regularly pentagonal. The embryo is nearly half the length of the endosperm, but it is very erratic in its behaviour inasmuch as the cotyledons sometimes have their backs to the axis (which is probably the most typical case), sometimes their edges, or again are placed obliquely, that is, diagonally to it. The various inclinations seem to be assumed indifferently, and the embryos even frequently occupy different positions in the two halves or mericarps of each fruit.

*Seedlings.*—While still in the seed the width of the cotyledons is limited by that of the seed itself.

After germination, however, they may become more or less modified by further growth; but the form they attain in the seed becomes deeply impressed upon them, and the chief alteration is in length, especially in that of the petioles.

Those observed may be arranged in five groups more for convenience' sake than from absolute distinction between the several types, for there is every intermediate gradation. In the first may be classified all those in which the lamina of the cotyledons is short and relatively broad. It varies from ovate, spatulate, and oblong to oval, and is generally if not always distinctly petiolate with the petioles free, or connate at the very base only. The cotyledons of *Hydrocotyle vulgaris* (fig. 405) are ovate, subsessile, and very small. They exactly correspond with the size and shape of the mericarps. The

leaves are peltate, orbicular, and crenate from the first, or, the first one is sometimes reniform and nearly or quite entire. The cotyledons of *Trachymene pilosa* are oblong-spathulate, trinerved and minutely emarginate. Those of *T. pusilla* are slightly broader; and both correspond fairly to the shape of the carpels. In their herbage they bear a striking resemblance to the mossy-leaved *Saxifrages*. The first leaf is trifid, followed by some that are tripartite with cuneate, trifid segments, and ultimately by others that are tripartite with entire segments. The cotyledons of *Eryngium paniculatum* (fig. 407) are also spathulate, but very small, while the primary leaves vary from suborbicular through spathulate to elliptic with spiny-serrate margins. The first leaves of *E. pandanifolium* are similar but less prominently spiny-serrate. The first two of *Bifora Biebersteinii* are broadly triangular and trifid, followed by a pinnatisect leaf, then by another that is two to three times cut in the same way.

The cotyledons are oblong, and trinerved with long petioles; and those of *Coriandrum sativum* are closely similar. There is also a marked similarity between the primary leaves of both species, as well as the ultimate ones. The cotyledons of *Eryngium giganteum* are broadly oval and trinerved.

The first two leaves are reniform, followed by others which are cordate in outline, but somewhat variable in detail. The petioles of the cotyledons are elongated and slender. *Heracleum Sprengelianum* connects this group with the next, for the difference is only one of degree. The elliptic lamina of the cotyledons is three- to five-nerved. The first leaf is cordate, five-nerved, and shallowly five-lobed. The first leaf of *Heracleum villosum* (fig. 416) is roundly cordate and crenate, while the laminae of the cotyledons are linear-oblong and sometimes very unequal. Those of *Peucedanum sativum* (fig. 415) are similar, but occasionally there are three cotyledons, sometimes two and bipartite.

The third group includes a number of species where the lamina of the cotyledons is short, broad and trinerved, but the petioles are elongated and connate into one cylindrical piece, or are much less decidedly connate, sheathing the younger leaves. This peculiar behaviour is due to the

hypocotyl being very short or undeveloped and subterranean. The long petioles carry the lamina up to the light, and their union gives strength or rigidity while the material necessary for the production of two strong petioles is economised. This type is well represented by *Smyrniium perfoliatum* (fig. 408). The combined petioles strongly resemble a slender, terete hypocotyl, and while we are expecting to see the plumule emerge from between the free portions, a leaf makes its appearance from the soil. Examination shows that it proceeds from a cleft at the very base of the united petioles and directly abutting upon the hypocotyl which soon becomes fleshy and tuberous in its nature. The first leaf has a tripartite lamina. During the germination of the embryo the broad cotyledons are able to make their exit from the globular concave seed by the splitting of the crustaceous exocarp. Both this species and *S. rotundifolium* have emarginate cotyledons, and they, together with *S. Olusatrum*, closely agree in all main particulars. *Ferula fœtida* and *F. communis* may be placed here because their petioles are connate at the base. The petioles with the linear-lanceolate lamina of the former measure about 14 cm. long; but the petioles are connate for a distance of 8–10 mm. only. The first two leaves have a tripartite lamina. The cotyledons of *F. communis* are very much shorter, trinerved, linear; and the petioles are connate for 7–8·5 mm. at the base. The first leaf is bi- to tri-pinnatisect. The long narrow cotyledons do not correspond with the large oval or elliptic dorsally compressed seeds.

In the fourth group may be included all those species having linear petiolate cotyledons of moderate length, as represented by *Bupleurum fruticosum*. The first four leaves are obovate, the ultimate ones oblong-obovate. *B. longifolium* and *B. falcatum* agree in all respects except in having narrower leaves. The species belonging to this genus are remarkable amongst the Umbelliferae for their entire leaves. Other species agreeing with the above in respect of the cotyledons are *Ammi glaucifolium* (fig. 409), *Chærophylum aureum*, *Carum Carvi*, *Ptychotis Ajowan*, and *Daucus Carota*. *Ammi glaucifolium* shows well-marked evolution of the leaves, the

first one being suborbicular and dentate; the second and third oblong, subcordate, and finely serrate; while the fourth is tripartite with leaflet-like segments. The first leaf of *Carum Carvi* is ternately cut nearly to the base; that of *Ptychotis Ajowan* (fig. 412) is tripartite with cuneate segments; and *Daucus Carota* is closely similar.

The fifth group includes a number of species with linear or narrowly linear greatly elongated cotyledons. Those of *Fœniculum vulgare* (fig. 413) are 3-3.5 cm. long. The primary leaves generally show a high state of division. In this case the first is bipinnatisect at the base with linear segments; and the second is three or four times pinnatisect. *Cuminum Cyminum*, *Myrrhis odorata*, *Scandix Pecten-Veneris* and *Aciphylla squarrosa* (fig. 414) also agree in having narrow cotyledons. Those of *Myrrhis odorata* vary from 9-11.2 cm. in length, and are distinctly widened above the middle, beneath which they taper into the greatly elongated petiole. The first leaf is bi- to tri-pinnatifid. That of *Scandix Pecten-Veneris* is tripinnatifid, with short, lanceolate segments; and the second is even more divided. The cotyledons are exceedingly narrow and 6.4-6.8 cm. long. Those of *Aciphylla squarrosa* are 3.6-4.3 cm. long, narrowly linear, scarcely tapered to the sheathing base, coriaceous and persistent, a very unusual circumstance in the Order. A considerable number of the primary leaves of this remarkable plant resemble the cotyledons, but are several times longer and tipped with a spine. The first three are linear and entire; the fourth with one lateral segment; the fifth with two lateral segments, followed by a number which are again entire. Divided leaves may, however, vary in their sequence in different seedlings. The ultimate leaves are bipinnatisect with linear, entire, spiny-tipped divaricate segments, arranged at least in two different planes.

***Hydrocotyle vulgaris*, L. (fig. 405).**

*Primary root* slender, flexuose, with a few lateral rootlets.

*Hypocotyl* pale greenish, tapering downwards, about 3 mm. long.

*Cotyledons* small, subsessile, ovate, obtuse or subacute, glabrous, 2.75 mm. long, 2 mm. wide, petiole about .5-1 mm. long.

*Stem* herbaceous, procumbent, creeping and rooting, terete,

glabrous, pale green; 1st, 2nd, and 3rd internodes undeveloped; 4th 5.5 mm.; 5th 9.5 mm. long.

*Leaves* simple, radical, alternate, exstipulate, petiolate, glabrous, peltate, orbicular, crenate.

No. 1. Orbicular, entire, or obscurely crenate, or frequently

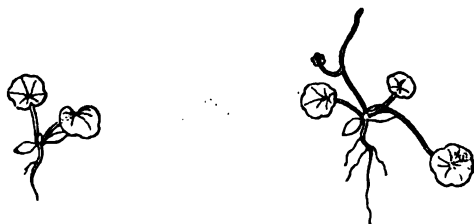


FIG. 405.—*Hydrocotyle vulgaris*. Nat. size.

dentate, sometimes reniform, or if orbicular with a more or less open sinus and not peltate, obscurely five-nerved.

No. 2. Peltate, seven-nerved and shallowly crenate.

No. 3. Similar but larger.

Ultimate leaves orbicular, peltate, seven- to nine-nerved, and lobulate-crenate or doubly crenate, glabrous and bright shining green above, paler beneath, and very thinly hairy or glabrous; veins slightly branching and reticulate towards the apex; petioles variable in length according to position and moisture, terete, hairy near the top, otherwise glabrous. The plant grows in marshy places.

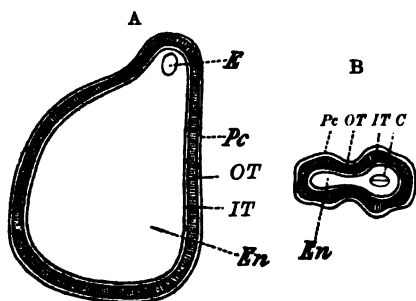


FIG. 406.—*Trachymene pilosa*,  $\times 10$ .

A, longitudinal section of mericarp. B, transverse section: E, embryo; Pc, pericarp; OT, testa; IT, tegmen; En, endosperm; C, cotyledons.

*Trachymene pilosa*, Sm. (fig. 406).

*Fruit* a cremocarp of two mericarps; commissure very narrow; mericarps laterally compressed.

*Seed* laterally much compressed, flat, conforming to the fruit.

*Embryo* minute, straight; cotyledons rounded, short and comparatively broad, lying in the broad plane of the seed with their edges to the placenta, plano-convex; radicle very short, blunt. This position of the embryo is very exceptional in the Order.



**Seedling.**

*Primary root* long, tapering downwards, more or less flexuose, with a few lateral rootlets, colourless, annual.

*Hypocotyl* erect, terete, thinly hairy, and densely covered with small, elevated, gland-like points, deep red, tapering insensibly into the root, 2.4–2.8 cm. long.

*Cotyledons* oblong-spathulate, petiolate, obtuse, minutely emarginate, with a distinct midrib, alternately trinerved from the middle upwards, but the nerves only visible on the under side, densely pubescent, and more or less glandular on both surfaces, dull green above, paler beneath or stained with red; lamina 9.5–11 mm. long, 5.5–7 mm. wide, tapered into the petiole; petiole grooved above, convex on the back, connate at the base, pubescent and more or less glandular, 6.5–7.5 mm. long.

*Stem* herbaceous, annual, erect, terete, branching and flexuose, or zigzag, densely glandular-hairy; 1st and 2nd internodes undeveloped; 3rd .5 mm. long; 4th 3–4 mm.; 5th 1.8–2.2 cm.

*Leaves* simple, tri-fid, -lobed or -sect, cauline, or the first two radical, alternate, exstipulate, petiolate, palmately trinerved from the base, glandular-hairy on both surfaces, deep green above and shining, much paler beneath; petiole semiterete, channelled above, glandular-hairy, tapering upwards from a broadish, semi-amplexicaul base.

No. 1. Cuneate, trifid; segments short, oblong, minutely cuspidate, obtuse.

No. 2. Broadly cuneate, trifid; middle segment oblong, obtuse minutely cuspidate; lateral segments oblong, bidentate at the apex; apices minutely cuspidate.

No. 3. Palmately tripartite; middle segment spathulate-cuneate, tridentate at apex; lateral segments obliquely cuneate and unequally trifid.

No. 4. Palmately tripartite; middle segment spathulate-cuneate, trifid and slightly dentate; lateral segments cuneate, unequally trifid, and slightly dentate.

Nos. 5 and 6. Deeply tripartite, with narrower segments than the fourth.

The specimens after this were showing flower, while the leaves gradually became reduced, palmately tripartite, with linear, trifid, or tridentate or entire segments.

Like its congener, *T. pusilla*, it resembles a species of *Saxifrage*.

*Eryngium paniculatum*, Cav. (fig. 407).

*Hypocotyl* subterranean.

*Cotyledons* spathulate, obtuse or emarginate, pale or grass-green 7 mm. long, 3·5 mm. wide, glabrous.

*Stem* herbaceous and elongated when about to flower.

*Leaves* simple, radical and cauline, alternate, exstipulate, sessile, dilated and sheathing at the base, glabrous, grass-green and lucid.

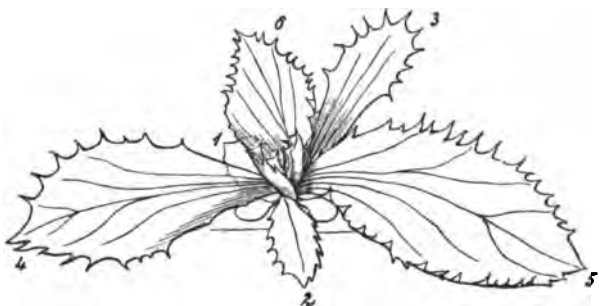


FIG. 407.—*Eryngium paniculatum*. Nat. size.

No. 1. Small, spatulate-rotund, acutely dentate.

No. 2. Small, oblong-elliptic, acutely spiny-serrate.

No. 3. Spathulate, acutely spiny-serrate.

No. 4. Spathulate-obovate, acutely spiny-serrate, and sparsely setose between the serratures.

No. 5. Oblong-elliptical, acute, otherwise like No 4.

***Eryngium giganteum*, M. Bieb.**

*Hypocotyl* very stout, fleshy, colourless, tapering downwards.

*Cotyledons* foliaceous, petiolate, glabrous; lamina oval, minutely emarginate, trinerved and reticulate, grass-green, shining, 6 cm. long, 1 cm. wide; petiole slightly grooved above, 1·6 cm. long.

*Stem* herbaceous and developed when about to flower.

*Leaves* simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, bright green, shining, five-nerved and reticulate; petioles subterete, channelled above, dilated and clasping at the base.

No. 1. Suborbicular, cordate at the base, crenate.

No. 2. Broadly cordate, very obtuse, crenate,

Nos. 3 and 4. Cordate, subelongate, very obtuse, unequally crenate.

Ultimate leaves, both the radical and lower cauline ones, cordate, obtuse or subacute, irregularly crenate-dentate, with long petioles. Middle cauline, cordate-elongate, upper ones cordate, and both sessile, amplexicaul, deeply and acutely spiny-serrate.

*Smyrniurn perfoliatum* Mill. (fig. 408).

*Primary root* very stout, forming a long tapering tap root, biennial.

*Hypocotyl* undeveloped.

*Cotyledons* oblong-elliptic, emarginate, obtuse, generally unequal-sided or subfalcate, with long petioles, trinnerved from the base and finely reticulate, with the lateral nerves becoming incurved and uniting with the midrib close to the apex, glabrous, light green above, paler beneath, shining on both surfaces; lamina 1·8–2·4 cm. long, 8·5–11 mm. wide; petioles 6–10 cm. long, connate into one terete piece for 5·5–7·5 cm. of their length, split a little way at the base to allow the plumule to emerge, free in the upper part, semiterete and slightly channelled above, glabrous, dull brownish-green.

*Stem* developed when about to flower; primary internodes undeveloped.

*Leaves* simple, trisect, ultimately ternately pinnatisect, radical and cauline, alternate, exstipulate, petiolate with the principal nerves opposite or subopposite, the others alternate, all ascending, glabrous, shining on both surfaces, bright green above, paler beneath; petioles semiterete, channelled above, glabrous, shining, dilated and sheathing at the base.

No. 1. Pinnately trisect; lateral segments broadly cuneate, unequal at the base on the posterior side, obtusely dentate-serrate on the upper half; terminal segment equal at the base, otherwise like the lateral ones.

*Bupleurum fruticosum*, L.

*Primary root* long, tapering, flexuose, colourless, with a few lateral rootlets.

*Hypocotyl* erect, terete, glabrous, purplish-brown or green 1·2 cm. long.

*Cotyledons* linear, obtuse or subacute, petiolate, glabrous, deep green with ascending petioles and a spreading or horizontal lamina, 2·4 cm. long including the petiole, 3 mm. wide about the middle of the lamina, slightly tapering to each end.

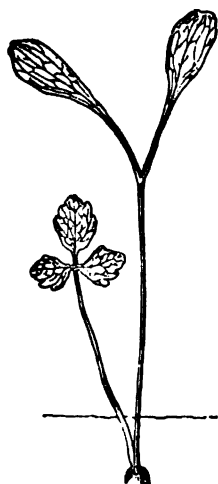


FIG. 408.  
*Smyrniurn perfoliatum*.  
Half nat. size.

*Stem* shrubby, erect, terete, glabrous, green stained with purple where exposed, covered with a glaucous bloom; 1st internode 5 mm. long; 2nd and 3rd each 5.5 mm.

*Leaves* simple, entire or merely emarginate on the adult plant, cauline, alternate, exstipulate, petiolate, glabrous, finely alternately penninerved, and finely reticulate, deep green above, paler and glaucous beneath, cartilaginous at the margin, apiculate; petioles channelled above, rounded on the back, glabrous, semiamplexicaul, rather long in the seedling, and almost or quite reduced to the sheath in the adult plant.

Nos 1 to 4. Obovate, obtuse, entire, apiculate.

Ultimate leaves oblong-obovate, emarginate, apiculate, with a midrib and two slender submarginal nerves, also two slender nerves at the base on each side of the midrib extending for half to three-quarters of an inch up and uniting each pair into one, which again runs along each side of the midrib till a little above the middle of the leaf, where it unites with the midrib, forming one nerve.

### ***Bupleurum longifolium*, L.**

*Primary root* and *hypocotyl* as in last species.

*Cotyledons* linear, subacute, widest about the middle, deep green, glabrous, about 1.8 cm. long including the petiole.

*Stem* herbaceous, annual, developed when about to flower.

*Leaves* simple, entire, radical and cauline, alternate, exstipulate, petiolate, glabrous, scabrous on the margin and midrib beneath; petioles dilated and sheathing at the base, ridged and furrowed, channelled above, scabrous on the ridges.

No. 1. Small, obovate-spathulate, apiculate.

Nos. 2. and 3. Obovate, apiculate.

### ***Ammi glaucifolium*, L. (fig. 409).**

*Primary root* stout, tapering downward, and soon furnished with slender, short lateral rootlets.

*Hypocotyl* stout, tapering insensibly into the root, glabrous, flesh-coloured.

*Cotyledons* linear, obtuse, entire, petiolate, glabrous, tapering gradually into the petiole, dilated and connate at the base, forming a cup around the plumule, at length splitting on one side, alternately penninerved, with some of the nerves suddenly curved upwards and running parallel with the margin, while others proceed to the margin almost horizontally, 2.5–2.8 cm. long including the petiole, 2–3 mm. wide about the middle of the lamina which tapers to each end.

*Stem* herbaceous, erect, terete, glabrous, pale green ; 1st internode undeveloped, 2nd 4 mm. long ; 3rd 2·5 mm.

*Leaves* compound, radical and cauline, alternate, exstipulate, petiolate, glabrous, alternately penninerved with flexuose, much branched anastomosing nerves, shining on both surfaces, bright grass-green above, lighter green beneath ; petioles semiterete, deeply channelled above, tapering slightly upwards, dilated at the base and forming a long clasping sheath with broad hyaline edges, articulated with the lamina.

No. 1. Rotund, subtrifid and irregularly dentate-serrate, three- or five-nerved towards the base.

No. 2. Oval, obtuse, subcordate at the base, rather finely and acutely serrate.

No. 3. Oblong, subacute or acute, finely and acutely serrate.

No. 4. Similar, or in strong plants pinately trifoliolate ; lateral leaflets lanceolate, acute, sharply serrate, unequal at the base, sessile but articulated with the petiole ; terminal one much larger, lanceolate-ovate, acute, finely and acutely serrate.

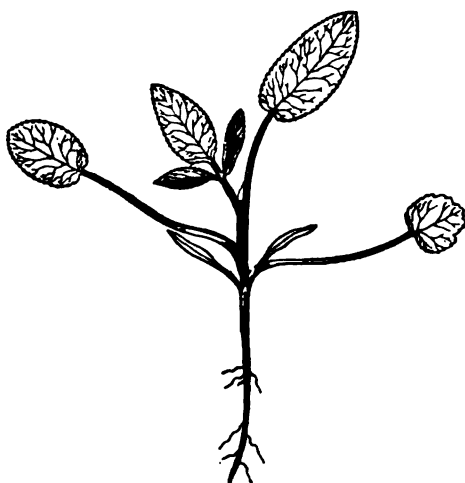


FIG. 409.—*Ammi glaucifolium*. Half nat. size.

*Carum Carvi*, *L.* (fig. 410).

*Cremocarp* ovate or oblong, obtuse, tipped by the small persistent calyx-teeth, and the stylopodium, glabrous, laterally compressed, attached to a shortly bifid carpophore and falling away in two pieces (mericarps) when mature ; mericarp oblong, slightly curved longitudinally, five-angled and five-sided with the commissural face slightly the broadest, the primary ridges filiform and rather prominent and a comparatively large vitta between each ridge with two on the flattened commissural face, one on each side of a slender median ridge, one-celled, one-seeded, indehiscent.

*Seed* five-angled, flat on the commissural or ventral face, or showing a scarcely prominent median ridge, shallowly sulcate between the other ridges, filling and closely conforming to the

interior of the mericarp; hilum and micropyle contiguous, basal and superior.

*Endosperm* in the mature seed copious, fleshy, white, or nearly so.

*Embryo* large for the size of the fruit and the Order, straight, colourless; cotyledons oblong, obtuse, entire, plano-convex, slightly longer than the radicle, lying with their backs or their edges to the axis of the fruit, or diagonally; these positions seem to be taken indifferently, and two of them frequently in the same cremocarp; radicle oblong-terete, suddenly tapering to an obtuse point, close to the micropyle, but with a layer of endosperm surrounding it.

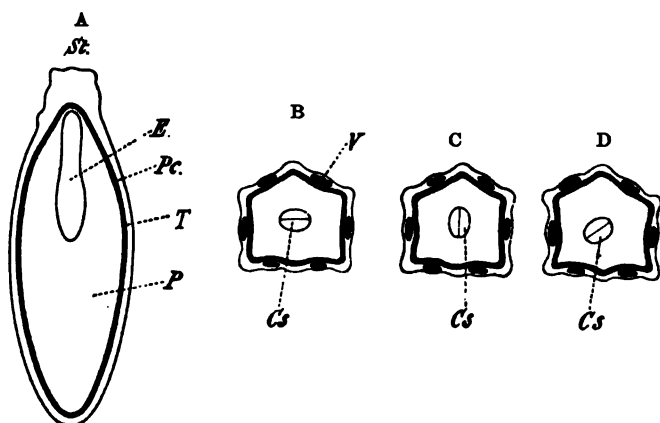


FIG. 410.—*Carum Carvi*,  $\times 10$ . A, longitudinal section of fruit: *St*, stylopodium; *E*, embryo; *Pc*, pericarp; *T*, testa; *P*, endosperm. B, transverse section of fruit: *V*, vitta or oil canal; *Cs*, cotyledons transversely to the axis of fruit. C, transverse section of fruit: *Cs*, cotyledons at right angles to the axis of fruit. D, transverse section of fruit: *Cs*, cotyledons, obliquely to the axis of fruit.

*Ptychotis Ajowan*, DC. (fig. 411).

*Cremocarp* ovate, laterally compressed, covered especially on the ridges with hardened protuberances or dried papillæ, tipped by the angled or knotty stylopodium and separating when mature into two mericarps. Carpophore bifid.

*Mericarp* ovoid with the commissural face the broadest, somewhat curved longitudinally; five-ridged, with the ridges slender, three dorsal and two on the edges of the ventral commissure, with a solitary vitta between each ridge, one-celled, one-seeded, indehiscent.

*Seed* oblong, subterete, slightly flattened on the ventral aspect, with a shallow, median, longitudinal ridge, closely conforming

to the interior of the mericarp, and adhering to it; testa thin, membranous, brown, inseparable from the pericarp; hilum and micropyle contiguous, basal, at the upper end of the seed.

*Endosperm* in the mature seed copious, fleshy, firm, white.

*Embryo* minute, straight, colourless, embedded in the endosperm close to the basal end of the seed; cotyledons oblong, obtuse, entire, plano-convex, lying in the centre of the endosperm, with their backs to the central axis of the fruit, and their edges to its compressed sides; radicle oblong-terete, obtuse, about as thick and as long as the cotyledons.

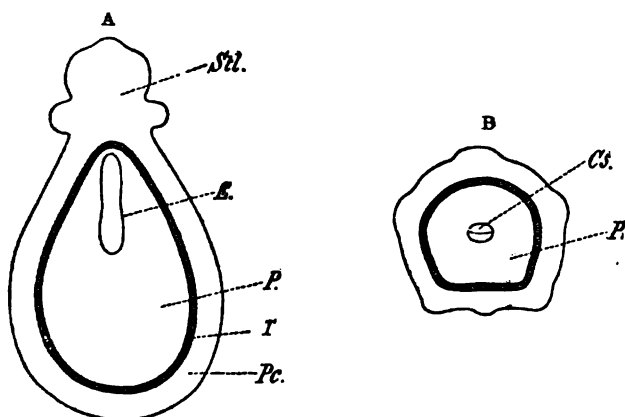


FIG. 411.—*Ptychotis Ajowan*,  $\times 24$ . A, longitudinal section of fruit: Pc, pericarp; T, testa; P, endosperm; E, embryo; Stl, stylopodium. B, transverse section of fruit: P, endosperm; Cs, cotyledons.

### Seedling (fig. 412).

*Primary root* small, colourless unbranched (at first).

*Hypocotyl* herbaceous, 3–4 cm. long, less than 1 mm. thick, glabrous, pale green.

*Cotyledons* 2.25 cm. long including the petiole; 2–2.5 mm. wide, lanceolate, tapering at the base, subacute at the apex, entire, with obscure midrib, glabrous, thin, light green; petiole long and slender.

*Stem* very short, glabrous, light green; 1st internode 3–4 mm. long, .75 mm. thick.

*Leaves* simple, radical and cauline, alternate, exstipulate, petiolate, ultimately ternately or pinnately multisect, with acute segments, glabrous, light green; petioles semiterete, channelled above, glabrous.

No. 1. With a glabrous petiole 3.5 cm. long, .75 mm. thick, and a ternatisect lamina 1 cm. long and as wide, obscurely nerved, glabrous.

No. 2. Ternatisect. Both are frequently much simpler than in the accompanying sketch.

No. 8. Pinnately multisect; pinnae cuneately palmate, bi-tri-sect with subulate or linear-subulate, acute or minutely apiculate segments.

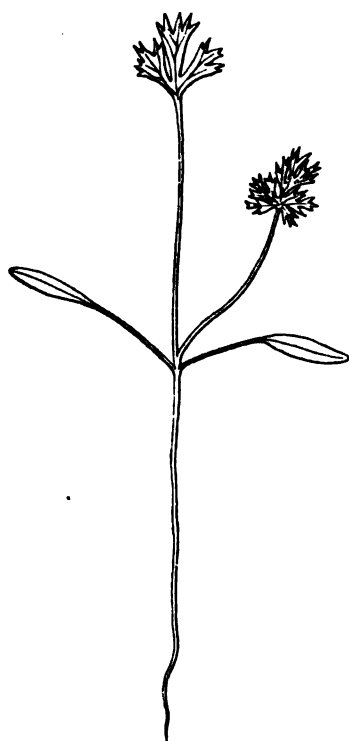


FIG. 412.—*Ptychotis Ajowan*. Nat. size.

### *Scandix Pecten-Veneris*, L.

*Primary root* long, tapering downwards, with slender, secondary rootlets.

*Hypocotyl* tapering insensibly into the root.

*Cotyledons* linear, obtuse, entire, tipped with a mucro, tapering gradually into the petiole, glabrous, shallowly grooved above, showing a distinct midrib on the under side, but no other discernible venation when fresh, but after a time slender alternate nerves; 6.4–6.8 cm. long, including the petiole, 1.5–2 mm. wide about the middle of the lamina which tapers to both ends, but more especially

the lower; petiole shallowly grooved above, dilated and connate at the base, forming a short sheath or cup around the plumule, and split a little more deeply on one side.

*Stem* herbaceous, erect, annual, produced only when about to flower; primary internodes undeveloped.

*Leaves* pinnately multisect, radical and cauline, alternate, exstipulate, petiolate, minutely pubescent or scaberulous at the edges of the segments, otherwise glabrous, deep green above, paler beneath, with a multifid branching venation corresponding to the segments into each of which a nerve runs; primary nerves opposite, secondary and higher ones alternate; petioles semiterete, channelled above, tapering somewhat upwards, dilated and sheathing at the base, minutely pubescent at the margins of the groove.



No. 1. Ovate-triangular in outline, tripinnatisect with small subulate or lanceolate, cuspidate segments.

No. 2. Triangular in outline, three to four times pinnatisect, with very small subulate or lanceolate, acute, segments.

*Fœniculum vulgare*, Gaertn. (fig. 418).

*Primary root* long, tapering downwards and giving off lateral fibres, colourless.

*Hypocotyl* undeveloped, or subterranean and indistinguishable from the root.

*Cotyledons* linear, obtuse, entire, petiolate, deep green, glabrous, with inconspicuous or indiscernible venation; lamina hardly broader than the petiole, and tapering insensibly into it, and together with the petiole 8-8.5 cm. long; petioles flattened or shallowly grooved above, dilated, and connate at the base forming a sheath or cup around the plumule, covered with earth at the base.

*Stem* herbaceous, forming a perennial rootstock, and throwing up annual flowering stems; primary internodes undeveloped.

*Leaves* simple, pinnately multisect, radical and cauline, alternate, exstipulate, petiolate, glabrous, deep glaucous-green, with primary, secondary, tertiary, and quaternary, alternate, ascending nerves; petioles much dilated and sheathing at the base, glabrous, deep glaucous-green; first one channelled above; second terete and slightly channelled towards the apex, substriate.

No. 1. Triangular, acute, bipinnatisect with linear acute segments, generally widest about the middle.

No. 2. Three to four times pinnatisect, with slender, linear, acute segments.

*Aciphylla squarrosa*, Forst. (fig. 414).

*Hypocotyl* subterranean.

*Cotyledons* linear, acute, coriaceous, flattened above, convex on the back, glabrous, lucid, dilated and sheathing at the base, pale green, 3.6-4.8 cm. long, 1 mm. wide.



FIG. 418.  
*Fœniculum vulgare*  
Half nat. size.

*Stem* not elongating till about to flower.

*Leaves* simple, entire in the first few of the seedling, ultimately bipinnatisect, glabrous, radical, alternate, exstipulate, sessile, scabrous at the margins and densely dotted with sunken glands, green or glaucous, rigid with divaricate spiny-tipped segments.

Nos. 1-3. Linear, spiny-tipped, entire.

No. 4. With one lateral segment.

No. 5. With two lateral segments; all linear.

Nos. 6-9. Linear, entire; but individual seedlings vary to some extent.

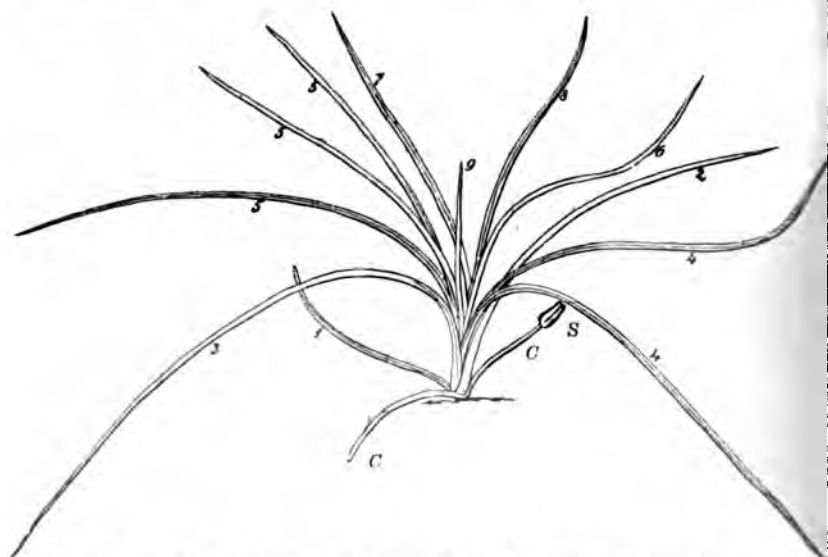


FIG. 414.—*Aciphylla squarrosa*. Half nat. size. *CC*, cotyledons; *S*, seed.

***Ferula communis*, L.**

*Primary root* long, tapering downwards, stout and furnished with lateral rootlets.

*Hypocotyl* short, subterranean or undeveloped, or indistinguishable from the root.

*Cotyledons* linear, obtuse, with long petioles, tapering slightly to an obtuse point and gradually into the petiole, appearing ternerved from the union of two to three alternate nerves on each side of and parallel with the midrib, glabrous and shining on both surfaces, deep green above, paler beneath; lamina 2·7-4·5 cm. long, 4·5-5·5 mm. wide; petiole 3·4-4·4 cm. long, plano-convex, dilated

at the base, connate and sheathing the plumule for 7-8.5 mm. at the base, and often splitting there on one side.

*Stem* herbaceous, forming a perennial rootstock, and sending up annual flowering stems; primary internodes undeveloped.

*Leaves* pinnately multisect, chiefly radical, the cauline smaller, alternate, exstipulate, petiolate, with a venation corresponding to the divisions of the leaf, each segment of which has a primary nerve, glabrous, shining on both surfaces, deep green above, paler beneath; petiole subterete, or laterally compressed, shallowly channelled above, thicker dorso-ventrally than in the other direction, glabrous, covered with a glaucous bloom, striated longitudinally, dilated and sheathing at the base.

No. 1. Pinnately tri- or slightly quadri-sect with the ultimate divisions subulate or linear, acute, with colourless tips.

*Ferula foetida*, Bunge.

*Primary root* as in last species.

*Hypocotyl* undeveloped.

*Cotyledons* linear-lanceolate, obtuse, entire, gradually tapering into the long petiole, glabrous, shining on both surfaces, deep green above, paler beneath, with a distinct midrib but no other discernible venation in the fresh state, about 14 cm. long including the petiole, and 6 mm. wide about the middle of the lamina; petioles semiterete, flattened above, with obtuse edges connate for 8-10 mm. at the base, forming a sheath around the plumule and afterwards splitting on one side, glabrous, green, stained with red.

*Stem* herbaceous, perennial, developing in length only when about to flower; primary internodes undeveloped.

*Leaves* simple, radical and cauline, alternate, exstipulate, petiolate, alternately and ascendingly penninerved, reticulate, glabrous except the petioles, deep green above, paler beneath, shining on both surfaces; petiole subterete, slightly flattened on the upper side, or subchannelled towards the apex, dilated and sheathing at the base, minutely and thinly pubescent, at least in the young state.

No. 1. Triangular, tripartite, with a long petiole; terminal lobe rhomboid-cuneate, trifid and serrate above the middle or towards the apex; lateral lobes spatulate-cuneate, serrate towards the apex.

No. 2. Similar, but having the lateral lobes broader and somewhat bifid.

*Peucedanum sativum*, L.

*Primary root* fleshy, or stout, tapering, colourless, with lateral fibres.

*Hypocotyl* very short or indistinguishable from the radicle.

*Cotyledons* linear or oblong-linear, obtuse, entire, with a strong midrib, and alternate, lateral, ascending nerves, reticulate, petiolate, and tapering into the petiole, glabrous; lamina 1.5–1.8 cm. long, 8.5–5 mm. wide; petiole flattened above, or shallowly grooved, convex on the back, dilated at the base and perfoliate, glabrous, 4.5–11 mm. long. Individuals occur very frequently in which one or both (fig. 415) of the cotyledons are bifid, bipartite, or divided to the base, appearing in the last case double, that is, simulating three or four cotyledons, instead of two. Where fission occurs there is a distinct midrib to each lobe of the cotyledon.

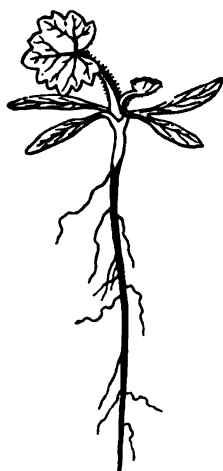


FIG. 415.  
*Peucedanum sativum*.  
Nat. size.

*Stem* elongated the second season when about to flower.

*Leaves* simple, radical and cauline, alternate, exstipulate, petiolate, glabrous or variously pubescent or hairy in wild plants; petioles more than half terete, narrowly and shallowly grooved above, glabrous or hairy, green or stained with purple, much dilated and sheathing at the base, striated with slender ridges.

No. 1. Cordate, obtuse, palmately five-nerved, obtusely crenate-dentate.

No. 2. Similar but trilobulate, and with overlapping auricles at the base.

Ultimate leaves pinnatisect; lateral lobes or segments cordate- or oblong-cordate, obtuse, with overlapping auricles at the base covering the primary midrib, alternately and ascendingly penninerved, lobulate, obtusely and cuspidately serrate-dentate, subreticulate, especially on the under surface.

### *Heracleum Sprengelianum*, *Wight et Arn.*

*Hypocotyl* subterranean, or 4–6 mm. exposed.

*Cotyledons* oblong, oval, or elliptic, entire, obtuse, 1.7–1.9 cm. long, 8–10 mm. wide, three- to five-nerved, glabrous, pale green, shining; petiole 1–2.2 cm. long, 1–2 mm. wide, flattened or sub-channelled above, convex beneath, glabrous.

*Leaves* radical, alternate, petiolate; petiole dilated and sheathing at the base.

No. 1. Cordate, obtuse, shallowly five-lobed, obtusely dentate or crenate, with mucro-tipped crenatures, palmately five-nerved

(in small or weakly seedlings tri-lobed and -nerved), pale green above and coarsely hairy, paler and almost villous beneath, ultimately pubescent on both surfaces; petiole subterete, shallowly channelled on the upper side, pale green and subvillous on the upper half, reddish and coarsely hairy on the lower, long, but length variable.

Intermediate forms are trifid, tripartite or trisect, with lobulate and dentate-serrate divisions. Further developed leaves are triangular, acute, pinnatisect and deeply pinnatifid; primary divisions triangular, acute, deeply pinnatifid and lobulate, dentate-serrate; terminal division broadly triangular, acute, deeply tripartite, lobulate and dentate-serrate.

*Heracleum villosum*, Fisch. (fig. 416).

*Primary root* stout, fleshy, tapering downwards and giving rise to short lateral fibrils, biennial.

*Hypocotyl* stout, fleshy, merging into the root.

*Cotyledons* sometimes rather unequal, linear-oblong, obtuse, tapering into the petiole, which is dilated and sheathing at the base, channelled above, glabrous, 2.6–8.9 cm. long, 5 mm. at the widest.

*Stem* herbaceous, undeveloped till it flowers.

*Leaves* simple, radical and cauline, alternate, exstipulate, petiolate, hispid, glandular and odorous; petiole channelled above, convex and ridged beneath, coarsely hairy, reddish at the base and pale green upwards, much dilated and sheathing at the base.

No. 1. Rotund-cordate, obtuse, palmately five-nerved, rather deeply crenate; crenatures mucronate.

No. 2. Palmately five-nerved, trilobed, cordate at the base, dentate-serrate with acute or mucronate serratures.

Intermediate forms are first triangular, trilobed, cordate at the base, and dentate-serrate.

Another stage in advance would be tripartite; lateral segments ovate, irregularly dentate-serrate; terminal lobe trifid and dentate-serrate.

Ultimate leaves pinnatipartite and deeply pinnatifid in the lower



FIG. 416.—*Heracleum villosum*.  
Half nat. size.

half, and deeply pinnatifid or bipinnatifid in the upper, shortly pubescent on both sides; ultimate lobes ovate or oblong-ovate, acuminate, irregularly dentate.

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## ARALIACEÆ.

Benth. et Hook. *Gen. Pl.* i. 931.

*Fruit and Seed.*—In the last Order the ovary was in all cases bicarpellary, and always two-celled except where the dissepiment ultimately became lost or aborted. The ovary in this case is also inferior, but possesses from two to many cells and as many carpels. In a few cases the number is reduced to one. The ovules are solitary in each cell, suspended from the apex of the cavity, and anatropous, with the raphe usually, if not always, ventral. The fruit is baccate or often drupaceous, with a fleshy, or rarely membranous exocarp. The endocarp is woody, crustaceous or cartilaginous, rarely membranous, and whatever the number of carpels making up the ovary, the endocarp of each is separately lignified, so that the fruit can be broken up into as many pieces as there were carpels. In multicarpellary fruits the seeds are more or less compressed laterally or subtriquetrous owing to the mutual pressure of the carpels to the interior of which they conform. The testa is always thin and membranous, and often closely applied or adnate to the endosperm which is copious and fleshy or cartilaginous, sometimes ruminated as in *Hedera*. The embryo is always minute and embedded in the endosperm close to the hilum; the cotyledons are rounded, ovate or oblong, and generally about the same breadth as the radicle.

Amongst the more exceptional cases in the Order are *Cuphocarpus* and *Arthrophyllum* with ovaries consisting of a single carpel, and *Tupidanthus* with nearly one hundred carpels. The fruit of *Horsfieldia* when mature separates into as many pieces as there are component carpels, and the parts of the fruit in several other genera are readily separable.

*Seedlings.*—The cotyledons amongst the few seedlings observed in this Order are ovate, petiolate and distinctly or indistinctly trinerved. Those of *Aralia edulis* (fig. 417)

are minutely but distinctly mucronate. The first leaf is reniform-cordate and serrate, followed by at least two others which are cordate and acuminate. The ultimate leaves are very large and bipinnate with serrate leaflets. The first two leaves of *Hedera Helix* (fig. 418) are trifid and palmately five-nerved, with the basal pair very slender. The next two give an indication of five lobes. The cotyledons are coriaceous, entire, and very persistent. The leaves of the first year's growth of *H. palmata* in the specimen noted by us differed from those of the type in the first one being reduced to a petiole (possibly accidental). The second showed an indication of five lobes; the third was small and terminated the first year's growth; the fourth and fifth were palmately five-lobed, very similar to those of the adult. A slight variation is shown by *Tupidanthus calypttratus* inasmuch as the cotyledons are relatively broader and distinctly emarginate. The first leaf is ovate, acute, tridentate and trinerved.

*Aralia edulis*, Sieb. et Zucc. (fig. 417).

Primary root tapering, flexuose, colourless, giving off a few lateral rootlets.

*Hypocotyl* erect, terete, glabrous, pale green, suffused with purple, 6 mm. long.

*Cotyledons* ovate, obtuse, mucronate, petiolate, glabrous, trinerved, subreticulate, lucid; lamina 8 mm. long, 6 mm. wide; petiole 3.5 mm. long.

*Stem* herbaceous, annually dying down to the rootstock.

*Leaves* compound (seedling or primary ones simple), radical and cauline, alternate, exstipulate, petiolate, thinly hairy on the nerves beneath, also pubescent above when young; deep green above, paler beneath, shining on both surfaces; petioles semiterete, deeply channelled above, slightly hairy, dilated and sheathing at the base; sheaths somewhat lacinate.

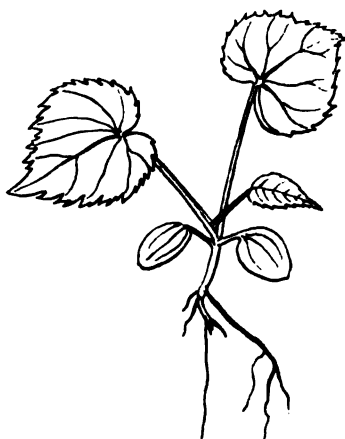


FIG. 417.—*Aralia edulis*. Nat. size.

No. 1. Cordate-reniform, acute, acutely and irregularly serrate, five-nerved.

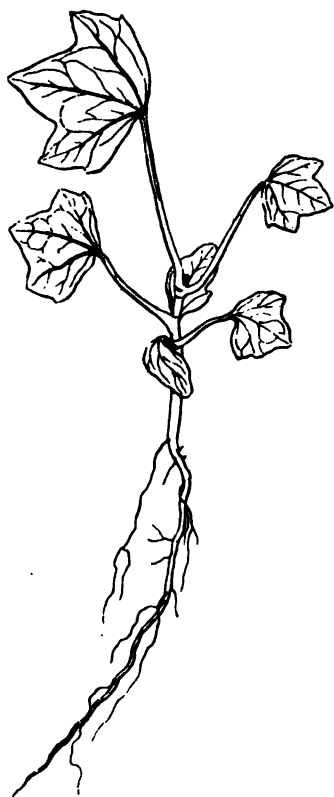
No. 2. Cordate, acute, seven-nerved, irregularly and acutely serrate.

No. 8. Cordate, acuminate, seven-nerved, irregularly and acutely serrate.

*Hedera Helix*, L., var. *palmata*.

Primary root tapering, flexuose, giving off numerous lateral, flexuose fibres.

*Hypocotyl* subflexuose, terete, glabrous, subverrucose, brownish, 2.2 cm. long, woody.



*Cotyledons* oval, obtuse, petiolate, subtrinerved and reticulate, foliaceous, deep green above, paler beneath, glabrous; petiole flattened above with a longitudinal median ridge, 6 mm. long.

*Stem* woody, terete, zigzag or subflexuose, pubescent with stellately branching hairs, pale green; 1st internode 1 mm. long; 2nd 5 mm.; 3rd 8 mm.; 4th 9 mm.; 5th 12 mm.

*Leaves* simple, cauline, alternate, exstipulate, petiolate (petiole with sheathing base), evergreen, pubescent with stellately branching hairs when young and unfolding, glabrescent when old except for a few hairs on the nerves, deep green above, reticulate, paler beneath.

No. 1. Reduced to a petiole, or limb, small.

No. 2. Palmately tri-fid and -nerved with a lateral tooth on each side foreshadowing two other lobes; lobes and teeth obtuse, mucronate.

No. 8. Very small, trifid.

No. 4. Palmately five-nerved and -lobed, subcuneate at the base;

lower nerve on each side slender and supported by a large lateral branch from the nerves above; two lateral lobes small, triangular; three middle lobes triangular-elongate, subacute or mucronate.

FIG. 418.—*Hedera Helix*. Half nat. size.



No. 5. Similar to No. 4, but not yet developed.

This variety differs from the type, *Hedera Helix* (fig. 418), in the fourth leaf, in the narrower and more elongated lobes, and the nerves ascending at a more acute angle.

***Tupidanthus calyptratus*, Hook. f. et Thoms.**

*Hypocotyl* erect, thickest near the soil, square, glabrous, 3·5–4·5 cm. long, light green or almost colourless.

*Cotyledons* ovate-oblong, obtuse, emarginate, with short petioles, glabrous, light green, distinctly trinerved, like the foliage leaves.

*Stem* with primary internodes undeveloped.

*First leaf* simple, tridentate, cauline, alternate, exstipulate, petiolate, ovate, acute, glabrous, subshiny green, trinerved; petiole comparatively long, channelled on the upper side.

## CORNACEÆ.

Benth. et Hook. *Gen. Pl.* i. 947.

*Fruit and Seed.*—As in the two preceding Orders, the ovary here also is inferior. It has from one to four cells, with a solitary anatropous ovule in each, suspended from the top of the cavity, except in *Garrya* where there are two ovules in the one-celled ovary which is formed from two carpels. The raphe is lateral or dorsal, and the membranous testa is confluent with, or inseparable from the endosperm. The fruit is most often drupaceous with a fleshy or pulpy exocarp and a one- to four-celled woody endocarp, more rarely separable into two bony or crustaceous one-seeded pieces. The seed is large, oblong, or elongated cylindrical, sometimes compressed as in *Marlea*, ovoid as in *Aucuba*, or linear as in *Toricellia*. Endosperm is copious and fleshy; in *Alangium* it is ruminant. The embryo is comparatively large, cylindrical, and nearly as long as the endosperm, or the cotyledons are much wider, in some cases about equal to the width of the endosperm; it is fleshy in *Kaliphora*, but minute in *Griselinia*, *Aucuba* and *Toricellia*. The radicle is superior and terete when elongated.

*Cornus alba* is a fairly representative type. The oval cotyledons are trinerved and opposite, but sometimes oblique and slightly shorter than the terete radicle. One of the two

cells of the ovary is generally aborted while the greater part of the drupaceous fruit is occupied by one large seed. The ovary and fruit of *Aucuba japonica* are one-celled, and the latter contains a very large ovoid seed enclosing a minute embryo close to the upper end of the endosperm. The blunt radicle constitutes by far the larger part of the embryo and is much wider than the cotyledons. The latter are narrowly oblong in *Curtisia*, linear in *Corokia*, foliaceous, twisted and plicate in *Alangium*.

*Seedlings*.—Few of the members of this Order are often grown from seed, with exception of *Cornus*, *Aucuba*, *Griselinia*, *Garrya* and *Corokia*, and but a few species even of these. Seedlings are still less common. The seedlings of *Aucuba japonica* (fig. 419) are large and vigorous notwithstanding the diminutive size of the embryo while in the seed. This is to be accounted for by the large quantity of endosperm available during germination. The hypocotyl is very stout and elongated; and the cotyledons are ovate, obtuse, three- to five-nerved and entire. They seem to be exceeded in size by those of the variety named *A. j. ilicifolia*, which sometimes attain a length of 3.5 cm., and a breadth of 2.1 cm. The first two pairs of leaves are opposite, and ovate, with a few coarse teeth. The



FIG. 419.—*Aucuba japonica*. Nat. size.

seedling of *A. japonica* observed produced only one pair of leaves and went to rest with its bud covered by two pairs of

leaves reduced to scales. After a short time the latter dropped, and growth was resumed.

*Aucuba japonica*, *Thunb.* (fig. 419).

*Primary root* stout, fleshy, subflexuose, ultimately producing strong, fleshy lateral roots also subflexuose.

*Hypocotyl* woody, erect, terete, glabrous, pale green, about 8 cm. long.

*Cotyledons* oblong-ovate, obtuse, three- or sub-five-nerved, shortly petiolate; lamina 2·15 cm. long, 1-1·4 cm. wide.

*Stem* woody, erect, terete, glabrous, hairy when young, pale green; 1st internode 1·85 cm. long; 2nd 1 mm.; 3rd 5·5 mm.; 4th 1·05 cm.

*Leaves* simple, cauline, opposite, decussate, exstipulate, petiolate, glabrous, bright green and shining above, paler beneath, marked on both surfaces with yellow or creamy yellow blotches; petioles semi-terete, channelled above in seedling plants, flattened in the adult, pale green or purplish.

First pair ovate, acute, serrate-dentate with about two teeth on each side.

Growth stopped here, and recommenced after a time.

Second and third pairs reduced to small ovate-subulate, acute, deciduous or caducous scales, decussating with the normal-sized leaves.

Fourth pair oblong-lanceolate, acute with about two teeth on each side.

Ultimate leaves large, lanceolate-oblong, gradually narrowed to an obtuse point and cuspidate, distantly serrate-dentate on the upper half, alternately penninerved, rather obscurely reticulate.

## CAPRIFOLIACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1.

*Fruit and Seed.*—The ovary in this Order is inferior and consists of two to six carpels, most frequently three, and as many cells, except in the case of *Viburnum* which has only one cell or is spuriously two- to three-celled. Here as in other cases there is evidence of a reduction of the original number of perfect cells. The ovules are usually solitary, and suspended from the apex of each cell or they are numerous and inserted

on the inner angles of the cells as in *Leycesteria* and *Diervilla*, and anatropous with a dorsal or lateral raphe. The fruit is variable in different genera and either baccate, drupaceous, or dry and indehiscent, or capsular. In several species of *Lonicera* the baccate fruits are united laterally in pairs. When mature the number of cells is the same as in the ovary, or may be reduced to one by the breaking up of the septa; each cell is one- to many-seeded. In some genera the fruit is in a transition state, as the seeds in some of the cells become aborted when quite young; in some cases some of the cells contain only one seed, while other cells of the same fruit have many seeds. When the seeds are solitary they are generally large and conform to the shape of the cell; but when numerous they are small and subglobular or variously angled. The endocarp is sometimes leathery or subwoody in baccate fruits, and the testa membranous, as in *Viburnum*, or the testa may be leathery, crustaceous or spongy, or winged along one side. Endosperm is copious and fleshy. The embryo is generally very small, and embedded in the endosperm close to the hilum, or it may elongate till it nearly equals the endosperm in length, with ovate or oblong cotyledons and an elongated terete radicle.

The last case is illustrated by *Sambucus nigra*, the fruit of which is baccate and three-celled, with the endocarp of each carpel forming a long thick layer enclosing and protecting a solitary, oblong seed, with a very thin testa and a lateral raphe.

The fruits of *Viburnum* are baccate or dry and indehiscent, globose or variously compressed or terete, and one- or spuriously three-celled. The endocarp is leathery or bony; and the solitary seed varies greatly in shape; the testa is membranous, the raphe lateral, and the embryo minute. They may be divided into three groups, the first of which is typified by *V. Opulus*. Although the fruit is globose, the endocarp and seed are much compressed. In a few exceptional cases the fruit is bluntly trigonous with a rather sharply trigonous endocarp and seed, pointing to the ancestral condition of the tricarpellary ovary.

In the young fruit the endocarp and seed seem to be gene-

rally slightly trigonous. The lateral raphe (see p. 50) almost entirely encompasses the seeds, a very exceptional case in any Natural Order of Phanerogams. The cell of the young ovary greatly exceeds the ovule in size; and the latter hangs suspended from the top of the cavity with the raphe already passing along one side, across the end and partly up the opposite side to the chalaza. The ultimate condition of the raphe seems to be due to a localisation of growth in the lower part of the seed; so that while the latter is making an effort to occupy the cell which it ultimately completely fills, the chalaza and that part of the seed above it remain stationary, while the lower part lengthens. The raphe in fact does not creep round the edge of the seed, but its great length is due to the inequality of growth in the upper and lower halves. The endocarp and seed of *V. Lantana* and *V. Lentago* (fig. 423) agree with those of *V. Opulus* in all main particulars, but the fruits are much compressed. The seed of *V. Lantana* is suborbicular and dorso-ventrally much compressed; that of *V. Lentago* is more oblong and as much compressed except at the apex, where there is a short ridge or elevation, opposite which is the embryo, and the seed conforms to it at that point. The raphe here is even more extraordinary, for it encircles the seed almost back again to the hilum.

The second group is typified by *V. dentatum* (fig. 421), the seed of which is ovoid or subglobose, ridged on both sides at the top as in *V. Lentago*, but strongly inflexed at the sides, making it rather deeply concave on one side. This it does in conformity with the cavity of the endocarp, which indicates an ancestral three-celled condition of the ovary. The raphe almost completely encircles the seed, and is not strictly marginal except at the lower end. Elsewhere it is irregular and undulatory at some distance from the margin. The ovule and young seed behave in a similar manner to those of *V. Opulus*. The fruit, endocarp and seed of *V. montanum* (fig. 425) are very much like those of *V. dentatum*. The raphe differs chiefly in being distant from the much incurved edge of the seed at the lower end. The third group is represented by *V. lantanoides* (fig. 424).

The fruit is oblong-oval in outline, somewhat compressed, ridged at the top, and longitudinally furrowed on both sides. A transverse section shows that the endocarp, and seed are infolded at the sides. The raphe touches the edge of the seed at the lower end only. The strongest character of this type is the ruminated endosperm.

The ovary of *Symphoricarpus racemosus* is four-celled, and contains four to five ovules in each of two cells, with one in each of the other two. The latter only mature into perfect seeds, having a bony, white testa with a membranous inner layer. The endosperm is fissured or slightly hollow along the centre, and the embryo is minute with ovate-oblong cotyledons. The fruit is globose and baccate as in *Lonicera Periclymenum*; in the latter, although originally three-celled, it becomes one-celled by the destruction of the septa and contains few seeds. These are oblong, subcompressed and biconvex, with a crustaceous testa. The embryo is small, with oblong or ovate cotyledons.

*Seedlings.*—The cotyledons of the different species of this family observed attain a considerable size during and after germination, depending doubtless in a great measure upon the size and shape of the seed, together with the quantity of reserve-material. There is comparatively little variation amongst them, and typically they may be described as oblong, obtuse, entire, or incipiently emarginate, petiolate with two to three pairs of nerves arising from different points of the midrib, running longitudinally along the lamina, and some of them again as a rule uniting with the midrib below the apex. The petioles are slightly connate at the base. A good representative type is furnished by *Sambucus nigra* (fig. 420) having oblong-ovate cotyledons. An interesting case of evolution is shown by the primary leaves of the seedling. They are opposite, and the two first pairs are cordate, serrate, and simple. Those of the third pair are pinnately trifoliate with broadly ovate leaflets. The cotyledons of *Viburnum punctatum* (fig. 426) differ chiefly from those of *Sambucus nigra* in being seven-nerved. The leaves are all simple, opposite and decussate, with the first pair ovate-elliptic and bluntly serrate. The succeeding five pairs are more decidedly

elliptic. The cotyledons of *Triosteum pinnatifidum* are broadly oblong and trinerved, with the petioles connate, so as to form a short tube around the axis. The leaves are dimorphic. The two first pairs are lanceolate, while those produced on the seedling when growth is resumed the following spring are broader and lanceolate-elliptic, while others are rhomboid and deeply trilobed on one side only, with rounded sinuses, ovate lateral lobes and broadly triangular terminal ones. The cotyledons of *Lonicera Munroi* (fig. 427) are oblong-oval, with two pairs of lateral incurved nerves arising at different levels on the midrib. The first four pairs of leaves are broadly oval, entire, and suddenly cuneate at the base. The cotyledons of *Viburnum Opulus* (fig. 422) differ from any of the above in being oblong, relatively longer, narrower and sessile. They have two pairs of lateral nerves with a considerable interval between them, and they suddenly taper to a connate base. The first pair of leaves are ovate with two pairs of coarse lateral teeth or lobes each with a strong nerve, arising alternately from the midrib. The seedlings took nearly seven months to germinate in a greenhouse temperature, from the 9th of October to the 1st of May following. The leathery or subwoody endocarp splits along the edges for the lower half of its length in order to favour the exit of the cotyledons.

***Sambucus nigra*, L.**

*Ovary* of two to five, usually three, carpels, two- to five-, usually three-celled, each cell one-ovuled; ovules pendulous, anatropous; micropyle superior.

*Fruit* baccate, globose, glabrous, tipped with the persistent lobes of the calyx, two- to five-, usually three-seeded; epicarp thin; mesocarp pulpy or juicy; endocarp bony, whitish, acting as a protection to the seed.

*Seed* narrowly oblong, obtuse at either end, conforming rather closely to the interior of the bony endocarp; testa very thin, membranous; raphe lateral, forming a ridge on the testa; micropyle and hilum basal at the upper end of the seed chalaza apical, at the lower end of the seed.

*Endosperm* copious, fleshy, transparent, white.

*Embryo* straight, narrow, central, nearly as long as the endo-

sperm, colourless; cotyledons oblong, obtuse, entire, many times shorter and slightly broader than the radicle; radicle cylindrical, obtuse, slightly narrower in the middle or at the end next the cotyledons, with its tip close to the micropyle, but within the endosperm.

**Seedling (fig. 420).**

*Primary root* slender, tapering, with a few fibrous lateral rootlets.

*Hypocotyl* tender, succulent, glabrous, or with a few short papillose hairs, erect, terete, pale green, 2.5 cm. long, 1 mm. thick.

*Cotyledons* foliaceous, glabrous; lamina oblong-ovate, obtuse, subcuneate at the base, bright green above, paler beneath, 1.5 cm. long, 8 mm. wide; petiole channelled above, connate around the stem at the base.



FIG. 420.—*Sambucus nigra*.  
Half nat. size.

*Stem* erect, terete, glabrous, green, succulent in the seedling stage, ultimately woody; 1st internode 2 mm. long, or hardly developed, and several succeeding ones similar.

*Leaves* simple (ultimately imparipinnate), cauline, opposite, stipulate; petiole subterete, channelled above.

First pair cordate, acute, acutely serrate, with five to seven ascending and incurved nerves, thinly pubescent in the young state.

Second pair similar.

Third pair pinnately trifoliate; leaflets broadly ovate, acute, acutely serrate; terminal leaflet much the largest.

**Viburnum, L.**

**EARLY DEVELOPMENT OF FRUIT AND SEED (fig. 421).**

The position of the raphe in this genus is interesting and peculiar.

At the time of flowering or immediately after the corolla has dropped, it passes (fig. 421, A) along one side of the ovule, across the lower and apical end, and a little way up the other side to the chalaza, which at this time is a little below the middle of the ovule.



Owing to a localisation of growth in the young seed, the lower and apical end including the raphe attains (fig. 421, B, C) great development. The seed being attached at the apex of the cell, is encouraged to grow at its lower end only, in order to completely occupy the cavity of the ovary. The distance between the chalaza and the

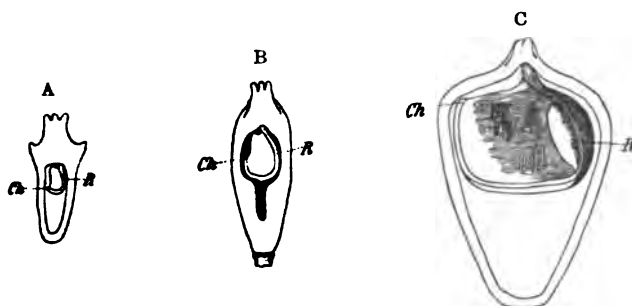


FIG. 421.—*Viburnum dentatum*. A, B, and C, longitudinal sections of the fruit in three stages,  $\times 5$ : R, raphe; Ch, chalaza.

hilum or micropyle remains unaltered, consequently as growth goes on the raphe seems to creep farther and farther round the seed, whereas it is only the lower part of the seed and the raphe which grow and develop together till the cavity of the ovary is completely filled, when the raphe surrounds nearly the whole of the mature seed.

### *Viburnum Opulus*, L.

*Ovary* of three carpels, one-celled, one-ovuled; ovule pendulous from the top of the inner angle of the cell, anatropous; micropyle superior.

*Fruit* a globose drupe, red when mature; mesocarp pulpy; endocarp horny.

*Seed* ovate-rotund, cuspidate at the apex, shallowly emarginate at the base, much compressed or flattened laterally, conforming to the interior of the endocarp, brownish-red, with a thin adherent testa; raphe lateral, passing along the edge of the seed, round the base and half way up the other side; hilum and micropyle superior, forming the cuspidate tip of the seed; chalaza about the middle of one edge.

*Endosperm* in the mature seed abundant, horny, white.

*Embryo* small, straight, embedded in the endosperm close to the hilum; cotyledons spatulate-oblong, obtuse, entire, about as long as the stout, obtuse radicle, and slightly broader than it, with their backs to the placenta in the broader plane of the seed.

## EARLY DEVELOPMENT OF FRUIT AND SEED.

Fruits frequently occur that are obtusely trigonous, indicating the ancestral form of the tricarpeal ovary, while in the young condition the cavity of the ovary is perhaps always slightly trigonous.

When the fruit has grown to some size, but long before maturity, the young growing seed is rotund-obovate or almost orbicular and very much shorter than the cell which it occupies.

The raphe at this stage passes round one side, along the apex, and a short way up the other side of the seed.

Further growth proceeds below the chalaza; the raphe also keeps pace with this localised growth and consequently attains its great length, nearly surrounding the margins of the flattened seed.

When the seed has attained full size, it is orbicular, or nearly so, biconvex or lenticular, and much compressed dorso-ventrally, rather acutely two-edged, and completely fills the cavity of the ovary; the raphe encompasses all but a short part of the edge, corresponding to the part above it in the ovule or exceeding it but a very little.

**Seedling (fig. 422).**

*Hypocotyl* erect, terete, glabrous, reddish, stout at the base and tapering upwards, 1-1.5 cm. above the soil.

*Cotyledons* oblong, obtuse or submucronate, entire, sessile, deep shining green, glabrous, tapering to the base and connate, trinerved at the base, with the nerves incurved about or below the middle, and uniting with other two that run nearly parallel with the midrib and margin, becoming incurved and uniting with the midrib close to the apex, slightly reticulate, 9-12 mm. long, 3-4 mm. wide.

*Stem* erect, two-angled in the earliest seedling form with the angles running down from the edges of the pair of leaves next above them, ultimately four- or many-angled or ridged and furrowed, glabrous, pale green, ultimately shrubby; 1st internode 6-15 mm. long.

*Leaves* simple, cauline, opposite, first few pairs exstipulate, ciliate, pubescent beneath, at least when young (first pair ciliate only), strongly palmately trinerved and lobate, coarsely, acutely and irregularly dentate, with the principal nerves again strongly alternately nerved and reticulate, deep green above, paler and shining

beneath; petioles semiterete, deeply channelled above, dilated at the base, amplexicaul and connate, thinly pubescent in the young state, glabrescent, furnished at the margins in the upper part with large, stipitate or sessile, green glands; stipules forming one to two linear, obtuse, or acute processes seated on the margin of the petiole and near its base, green, glabrous.

First pair of leaves ovate, acute, trilobed, with two large teeth near the base, alternately and ascendingly penninerved, with a strong nerve running into each lobe or tooth, ciliate, otherwise glabrous, light green and shining on both surfaces, exstipulate, with short red margined petioles.

Ultimate leaves palmately tri-nerved and -lobed, with the three principal nerves again strongly and ascendingly penninerved, reticulate; lobes acute, coarsely and irregularly dentate, with deltoid acute teeth; middle lobe the largest and on strong growing shoots often trifid.



FIG. 422.—*Viburnum Opulus*,  $\times 2$ .

***Viburnum Lentago*, L. (fig. 423).**

*Fruit* a drupe, globose or oblong, slightly compressed dorso-ventrally, glabrous, black; mesocarp pulpy, very dark-coloured; endocarp thick, tough, horny, separable into halves longitudinally along the edges, very much compressed dorso-ventrally, rounded at its lower end, cuspidate at the apex.

*Seed* orbicular or oblong, rounded at the lower end, but some-

times emarginate owing to a small indentation or inflection of the endocarp to which it conforms, cuspidate at the apex where the radicle lies; testa thin, membranous, minutely alveolate or honey-combed over great part of its surface, deep brown; hilum and micropyle contiguous, superior, or basal to the seed; raphe commencing at the hilum and forming a distinct line almost all round the margin of the seed.

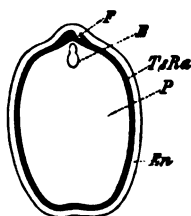


FIG. 423.—*Viburnum Lentago*. Longitudinal section of endocarp and seed,  $\times 2$ : F, funicle; E, embryo; T&Ra, testa and raphe combined; P, endosperm; En, endocarp.

### *Viburnum Lantana*, L.

*Drupe* oblong, dorso-ventrally compressed; endocarp pale- or straw-coloured, ridged and furrowed longitudinally in conformity with the seed; otherwise as in the last species.

*Seed* nearly orbicular, much compressed dorso-ventrally with a median longitudinal ridge along one face and a corresponding furrow along the other, pale brownish-orange; raphe lateral, passing from the hilum round one edge of the seed and half way up the other to the chalaza; otherwise as in the last species.

*Endosperm* and *embryo* as in previous species; cotyledons ovate; radicle about half their length.

### *Viburnum lantanoides*, Michx. (fig. 424).

*Drupe* oval-oblong, slightly compressed dorso-ventrally, narrowed

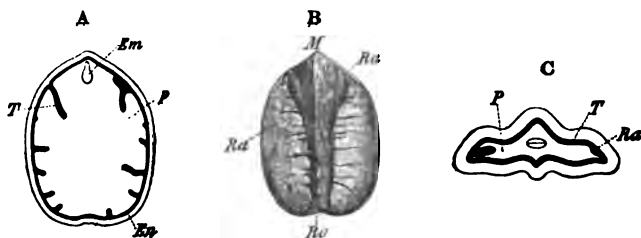


FIG. 424.—*Viburnum lantanoides*. A, longitudinal section of endocarp and seed,  $\times 8$ : Em, embryo; T, testa; P, endosperm; En, endocarp. B, seed,  $\times 8$ : Ra, Ra, raphe; M, micropyle. C, transverse section of endocarp and seed near its apex,  $\times 8$ : P, endosperm; T, testa; Ra, raphe.

to the apex and tipped with the persistent base of the style; mesocarp pulpy, dark-coloured; endocarp crustaceous, oblong, narrowed

at the upper and basal end into an obtuse tip, somewhat compressed dorso-ventrally, and raised on one face into four stout ridges with intermediate depressions, and having on the other a deep impression with a ridge in the centre, pale-coloured.

*Seed* conforming to the endocarp, dark brown, minutely pitted, glabrous; *testa* thin, membranous, carried in folds into the endosperm; *raphe* a reddish line passing from the hilum down the side of the seed, and winding round the end and up the opposite side for two-thirds of its length; *chalaza* within one-third of the base of the seed.

*Endosperm* as before, but ruminant.

*Embryo* as before; cotyledons oblong-ovate.

*Viburnum montanum*, ? *Auct.* (fig. 425).

*Drupe* obovoid; endocarp crustaceous and variously involuted owing to indentations or cavities of the seed, as well as its infolded margins.

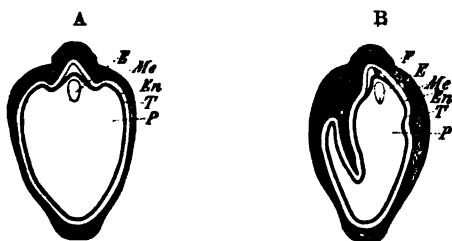


FIG. 425.—*Viburnum montanum*,  $\times 4$ . A, longitudinal section of fruit: E, embryo; Me, mesocarp; En, endocarp; T, testa; P, endosperm. B, longitudinal section through the narrow plane of the seed: F, funicle; E, embryo; Me, mesocarp; En, endocarp; T, testa; P, endosperm.

*Seed* somewhat obovoid, suddenly narrowed at its upper end, deeply infolded at the sides on the ventral aspect, and shallowly on the dorsal aspect near, or at the top, leaving a median ridge which contains the embryo; *raphe* lateral, passing round the seed just within the infolded margins and consequently appearing ventral; *chalaza* a short distance from the hilum; *testa* thin, membranous, pale yellowish.

*Endosperm* fleshy, pale yellowish or transparent, occupying almost the whole of the seed.

*Embryo* minute, ovoid-oblong, embedded in a thickened and pointed part of the endosperm close to the micropyle and hilum; *radicle* very blunt, subturinate, about equal to the cotyledons in length; cotyledons ovate, obtuse, entire, plano-convex, applied to each other face to face.

***Viburnum punctatum*, Hamilt. (fig. 426).**

*Hypocotyl* scurfy with deciduous scales, pale green, 3.6 cm. long.

*Cotyledons* foliaceous, oblong-ovate, obtuse, seven-nerved, with scurfy scales; lamina 1.7 cm. long, 9 mm. wide; petiole grooved over 2.5 mm. long.

*Stem* woody, erect, quadrangular, densely scurfy with brown scales; 1st internode 9 mm. long; 2nd and 3rd each 3.5 mm; 4th 6 mm.; 5th 7.5 mm.

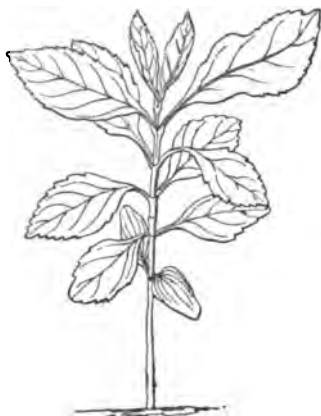


FIG. 426.—*Viburnum punctatum*.  
Half nat. size.

*Leaves* opposite, decussate, exstipulate, shining above and thinly scurfy, densely so beneath, alternately penninerved; petioles grooved above, subcarinate beneath with the carina continuous with the angles of the stem.

First pair ovate-elliptic, obtuse, mucronately serrate-dentate on the upper half.

Third, fourth, and fifth pairs elliptic, obtuse, mucronately serrate-dentate on the upper two-thirds.

Ultimate leaves oblong-elliptic, obtuse or acuminate, nearly smooth on the upper surface, and closely dotted with round scales beneath, alternately incurvinerved.

***Triosteum pinnatifidum*, Maxim.**

*Hypocotyl* 4–8 mm. above the soil.

*Cotyledons* broadly oblong, obtuse, entire with a prominent terminal gland or slightly emarginate, petiolate, conspicuously reticulated, with three nerves running from near the base to the apex of the lamina, light green above, paler beneath, glabrous; lamina 1–1.3 cm. long, 7–9 mm. wide; petiole erect, grooved above, connate at the base, forming a cylinder or tube round the stem.

*Stem* erect, terete, coarsely hairy, the shorter hairs bearing orange-coloured glands; 1st internode variable, 1–4.2 cm. long.

*Leaves* exstipulate, incurvinerved and prominently reticulated, hairy on both surfaces; petiole winged, owing to the decurrent lamina, slightly connate at the base, channelled above.

First and second pairs lanceolate, obtuse, or subacute, mucronate.

On one year old seedlings the leaves are broader and lanceolate to elliptic; some of them are rhomboid and deeply trilobed or cut on one side only with rounded sinuses, and the lateral lobes ovate, while the terminal ones are broadly triangular; base much decurrent on the shortened petiole. These cut leaves also appear irregularly amongst others, both above and below, which are entire.

***Symphoricarpus racemosus*, Michx.**

*Ovary* of four carpels, four-celled—two cells each with four to five aborted ovules—the other two each with a solitary pendulous anatropous perfect ovule; micropyle superior, close to the hilum.

*Fruit* a berry, globose, white, surmounted by four to five small teeth, the remains of the calyx, four-celled, with two perfect seeds.

*Seed* oval-oblong, slightly compressed dorso-ventrally, smooth, white; testa bony; tegmen thin, membranous, pale brown; hilum near the base (otherwise the upper end of the seed) forming a shallow cavity; raphe inconspicuous.

*Endosperm* and *embryo* as in *Viburnum*; cotyledons oblong-ovate; radicle cylindrical, equal to the cotyledons in length.

***Lonicera Periclymenum*, L., var. *serotinum*.**

*Ovary* crowned with the persistent calyx, of two to three carpels, two- to three-celled, many-ovuled; ovules pendulous from the apex of the cell, anatropous; micropyle superior.

*Fruit* a berry, globose, glabrous, red when mature, two- to three-celled or one-celled by the destruction of the septa, few-seeded; exocarp and endocarp thin, membranous; mesocarp pulpy.

*Seed* oblong, plano-convex, or somewhat biconvex, obtuse at each end, generally broadest at the apex, often appearing obliquely notched at the base owing to the hilum being slightly lateral; testa pale brownish-yellow, thick, crustaceous; tegmen thin, membranous; micropyle basal; raphe and chalaza inconspicuous.

*Endosperm* copious, fleshy, almost colourless, split down the centre a considerable way, but occupying the greater part of the seed.

*Embryo* small, straight, embedded in the endosperm close to the base of the seed; cotyledons oblong or ovate; radicle shortly oblong, suddenly narrowed to an obtuse point, nearly or quite as long as the cotyledons.

***Lonicera Munroi*, ? *Hort.* (fig. 427).**

*Primary root* very long, wiry, slender, with numerous slender lateral rootlets.

*Hypocotyl* erect, terete, glabrous, slender, purplish, 1.2-2.1 cm. long.

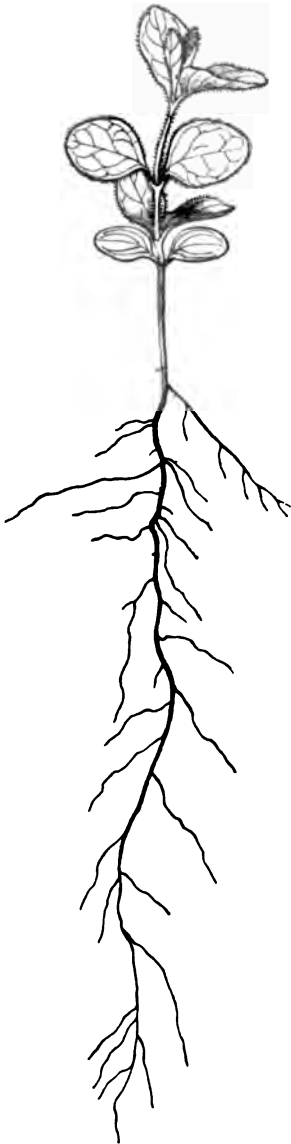


FIG. 427.—*Lonicera Munroi*.  
Nat. size.

*Cotyledons* oblong-oval, obtuse, entire or obsoletely emarginate, alternately nerved with one or two of the lower pairs stronger than the rest, if one pair they become incurved and unite with the midrib near the apex, while if two pairs are strongly developed they unite about the middle of the cotyledon and then proceed to the apex, shortly petiolate, glabrous, subglaucous-green, often stained beneath with purple; lamina 6-8 mm. long, 4-5 mm. wide; petiole channelled above, convex on the back, connate at the base around the plumule, purplish, 1-1.25 mm. long, ciliate at the margin.

*Stem* erect, terete, thinly hairy or pubescent, green or purplish, ultimately shrubby; 1st internode 1.25-2 mm. long; 2nd 1.75-6 mm.; 3rd 6-10 mm.

*Leaves* simple, entire, cauline, opposite, exstipulate, petiolate, young ones densely ciliate, and hairy on both surfaces, with the hairs curved or bent towards the apex, alternately and incurvedly penninerved, the nerves uniting and forming a series of large reticulations towards the margin, glaucous-green at least in the young state; petioles short, grooved above, subcarinate or merely convex beneath, slightly connate at the base, more or less hairy.

First and second pairs small, oval, obtuse, suddenly tapering to the base.

Third and fourth pairs oval, obtuse, often cuspidate, suddenly tapering to the base, somewhat larger than those below them.



*Lonicera media*, Murr.

*Hypocotyl* 8–12 mm. long, stained with red.

*Cotyledons* subrotund or ovate-oblong, obtuse, emarginate, petiolate, glabrous, subglaucous-green, distinctly trinerved, the nerves with numerous branched veinlets; when emerging from the seed some appear convolute, others not.

*Stem* erect, terete, herbaceous, ultimately woody; 1st internode 2–3 mm. long.

*First leaves* entire, oblong-lanceolate, obtuse, glabrous, green, distinctly pinnatinerved, exstipulate; petioles short, very shallowly furrowed on the upper side.

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## RUBIACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 7.

*Fruit and Seed*.—The ovary is inferior, crowned by a disc, and from one- to ten-celled. The ovules are numerous, twin, or solitary in each cell, and inserted on, or immersed in the placentas, or concave and surrounding them as in *Galium*, erect, ascending, horizontal, or pendulous, anatropous, semi-anatropous or amphitropous. The fruit is baccate, drupaceous, capsular or consists of dehiscent or indehiscent cocci, and varies with from two to ten, very rarely one cell. The seed varies greatly in size, and is immersed in the receptacle, or in pulp, or is quite free with a membranous, leathery, crustaceous or very rarely woody testa; it is however sometimes winged or appendiculate. Endosperm is usually copious, fleshy or horny, very rarely reduced to a thin layer or entirely wanting; it is either solid or ruminated. The embryo varies greatly in size, and is curved, straight or clavate. The cotyledons are flat, or semiterete, ovate or cordate, foliaceous, with a terete or clavate, superior or inferior radicle.

There are several distinct types of seeds in the Order. Exalbuminous seeds occur in species of *Henriquezia*, *Platycarpum*, and several of the tribe *Guettardeæ*. Ruminated seeds are met with in *Coptosperma*, *Galiniera*, *Rutidea*, *Polyphæria*, and in species of *Psychotriæ*.

The seeds of *Gardenia Thunbergia* vary greatly in outline, being oval, oblong, orbicular or more or less angled, but always much compressed and surrounded or embedded in the pulp of the baccate, one-celled fruit. They owe their shape to mutual compression while still young. The embryo is about half the length of the endosperm, but much narrower, with roundly triangular cotyledons and a terete radicle. *Genipa clusiæfolia* (fig. 430) also belongs to this type. The seeds of *Alberta magna* (fig. 433) are oblong, bluntly trigonous and conform to the cells of the ovary, of which there are four, two barren and two fertile, each containing a single ovule. The embryo nearly equals the endosperm in length, and is situated near the dorsal aspect of the seed. The cotyledons are shortly and bluntly ovate, while the terete radicle is many times longer. The fruit is dry and surmounted by five very unequal, foliaceous, coloured sepals, of which generally two are larger than the rest, trinerved, reticulate, and rose-coloured in the dry state. They seem to assist in the dispersion of the fruit.

In two widely distinct groups of plants represented by *Ixora* and *Galium*, the seeds are deeply concave or umbilicate on the ventral aspect. The globular drupaceous fruit of *Ixora congesta* (fig. 434) is two-celled with a semiorbicular seed in each cell conforming in shape to the cavity. The embryo is curved in conformity with the shape of the comparatively thin seed; but in other respects it closely resembles that of *Gardenia Thunbergia*. The half-fruits of *Galium Aparine* (fig. 439) and *G. saccharatum* (fig. 441) are subglobular and deeply concave. The embryo is embedded in the copious horny endosperm, close to the ventral aspect. The pericarp of *G. Aparine* is dry, membranous and thin, while that of *G. saccharatum* consists of a dense layer of dry corky tubercles. The embryo of the latter is considerably narrower than that of the former; and this circumstance seems to have reference to the mode of exit of the respective embryos during germination.

A fourth type of seed is represented by that of *Coffea arabica*. The fruit is oblong, drupaceous, and two-celled with each cell one-seeded. The seed is large, oblong, plano-convex,

corresponding in outline to one half of the fruit, and has a hard crustaceous testa. When mature, it shows a longitudinal slit or furrow in the middle or a little to one side of the ventral face. A transverse section of the seed shows that it grows much too wide for the cavity of the fruit, and becomes strongly infolded longitudinally with its lateral edges meeting on the ventral aspect. The embryo is like that of *Gardenia Thunbergia* and is located on the dorsal aspect at the lower end of the seed, with the radicle inferior as in the species of *Galium* and *Ixora*.

*Seedlings*.—There are many differences in matters of minor detail in seedlings of this Order ; but the prevailing type of cotyledon is ovate and three- to five-nerved, while broadly ovate-triangular and elliptic forms may be considered as modifications. Those observed may be conveniently classified into four groups according as the species are herbaceous with ovate cotyledons ; shrubby with ovate and generally larger cotyledons ; thirdly, have more or less elliptic cotyledons ; and, fourthly, orbicular or transversely oblong cotyledons. The first type is well represented by *Rubia cordifolia* (fig. 438). The cotyledons are ovate, five-nerved, and petiolate. The first pair of leaves are ovate-cordate, three- to five-nerved, and the stipules are similar but smaller, with less conspicuous venation. *Galium tenuissimum* has similar, but very small cotyledons, and the first three pairs of leaves are obovate and similar to, but slightly larger than, their stipules. *Crucianella ægyptiaca* (fig. 443) differs from the last named in the cotyledons being larger and emarginate. The first pair of leaves are lanceolate, and the four succeeding pairs linear-subulate with similar stipules. The seedling of *Galium Aparine* is almost as vigorous as that of *Rubia cordifolia*, but the cotyledons differ in being broadly oblong-ovate, trinerved, and emarginate. The broad cotyledons emerge from the thin-walled fruit by the splitting of the latter after the endosperm has been absorbed ; the emargination is sometimes quite evident as soon as they have escaped from the seed, but as a rule it is not noticeable till later ; it is due to the more rapid growth of the sides as compared with the apex where the water-pores, or at least the principal ones, are situated. The

increase in size that takes place after germination is shown at fig. 440, representing the exact nature of the venation in a bleached specimen. The lateral nerves, at first close to the margin all round, are ultimately distant from it. *Galium saccharatum* (fig. 442) differs remarkably from its congeners and others in this group, in having linear-oblong emarginate cotyledons. The venation (fig. 442, B), drawn from a bleached specimen, is strikingly different from that of *G. Aparine*, a fact apparently due to growth in the basal portion of the lamina subsequent to germination. The narrowness of the lamina is necessary to facilitate the escape of the embryo from the narrow opening of the fruit, which has a thick warted and cortical pericarp as above mentioned.

The shrubby type is represented by *Randia Mussændæ* (fig. 428) having large ovate cotyledons tapering to the base, with a penninerved, incurved venation resembling that of the leaves, the first pair of which are elliptic. *Leptodermis lanceolata* conforms pretty closely to this type, and an unnamed species of *Psychotria* (fig. 437) differs chiefly in the cotyledons being shorter, broader, and almost truncate at the base. The latter also furnishes a remarkable instance of the presence of stipules to the cotyledons. The first two pairs of leaves are elliptic, and, like the cotyledons, have incurved nerves. *Coffea arabica* (fig. 436) has roundly ovate strongly trinerved and reticulate cotyledons, larger than any others of the Order coming under my notice. The first four pairs of leaves are lanceolate-elliptic. *Ixora parviflora* has roundly triangular cotyledons with a cordate base and very prominent venation. As amongst the herbaceous types, so here we have a strong divergence from the usual form. The cotyledons of *Plectronia ventosa* are linear-oblong, obtuse, penninerved, sessile, and leathery like the leaves. The two first leaves are ovate. Another exceptional instance occurs in *Rudgea Hostmani* which has broadly reniform cotyledons, but in the specimen noted they were evidently malformed. The first pair of leaves are oblong; the second broader.

A few constituting a third group have elliptic cotyledons. Taking *Genipa clusiæfolia* (fig. 432) as a type, it will be seen that the cotyledons possess no very marked characters separat-

ing this from the last group, and while still in the seed and in the course of germination they are strictly ovate. After leaving the testa they elongate or become cuneate at the base and are then broadly oval or elliptic and trinerved. They are remarkable although not unique in being stipulate like the species of *Psychotria* above mentioned. While the cotyledons are still in the germinating seed (fig. 431) the stipules form minute protuberances covered with unicellular hairs. After germination and while the cotyledons are still broadly ovate, the stipules enlarge, and although still very small they serve to protect the plumule lying as a little bud between them. A more marked type is represented by *Morinda tinctoria*, the cotyledons of which are broadly elliptic and penninerved with ascending nerves as happens more commonly in true leaves. The first pair of the latter in this case are linear-lanceolate and many times narrower than the cotyledons. *Pavetta speciosa* may also be placed here. The cotyledons are penninerved and stipulate; and the two first pairs of leaves are oblong, tapering at the base. A fourth type includes those species having orbicular or transversely oblong cotyledons. An herbaceous type is represented by *Sherardia arvensis* (fig. 444) having orbicular entire trinerved cotyledons. The leaves closely correspond to those of *Galium*; the first pair are obovate, with smaller but similarly foliaceous stipules. In the next two whorls the leaves and stipules more nearly approximate in size, and there are only two stipules. As the plant assumes the adult form, the leaves become lanceolate and each pair possesses two pairs of stipules similar to themselves, making a whorl of six. *Pavetta madagascariensis* (fig. 435) is a shrubby type with transversely oblong or suborbicular cotyledons and triangular interpetiolar stipules. The two first pairs of leaves are elliptic-oblong. The cotyledons of *Gardenia globosa* are similar and trinerved, and the first three pairs of leaves are oblong, obtuse, and more or less pubescent. In *Gardenia Thunbergia* (fig. 429) the cotyledons are obovate, emarginate and penninerved. The first five pairs of leaves are obovate, penninerved and tapered to the base. The ultimate ones are lanceolate-elliptic, attenuated at the base and opposite, or in whorls of three.

**Randia Müssendæ, DC. (fig. 428).**

*Hypocotyl* woody, erect, terete, pubescent, pale green, about 1·4 cm. above the soil.

*Cotyledons* large, foliaceous, ovate, rounded at the apex, tapering to the base, alternately penninerved, but most conspicuously on the lower half, glabrous, coriaceous but thin, deep green and shining above, paler beneath, 2·1 cm. long, 1·5 cm. wide.

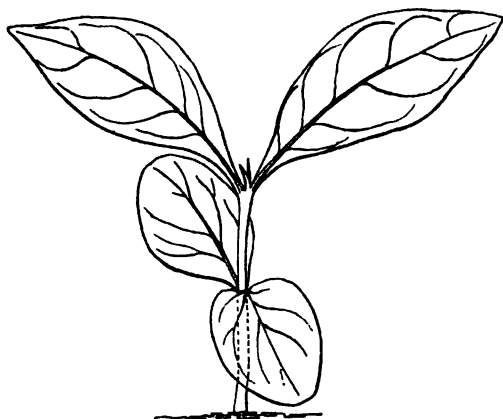


FIG. 428.- *Randia Müssendæ*. Nat. size.

*Stem* woody, erect, terete, pubescent, pale green; 1st internode 1·2 cm. long.

*Leaves* simple, entire, cauline, opposite, stipulate, shortly petiolate, bright green and shining above, thinly pubescent, ciliate, paler beneath and thinly pubescent on the nerves, alternately penninerved;

stipules interpetiolar, united and forming one subulate, attenuate piece between each pair of leaves; petioles flattened above, convex beneath, thickened at the base, very short, pubescent.

First pair lanceolate, subacute, tapering most at the base.

**Gardenia Thunbergia, L. fl.**

*Fruit* baccate, globose or ellipsoid, ultimately more or less cortical externally when dry, and crustaceous internally or somewhat bony, one-celled, many-seeded, indehiscent; placentas ultimately forming a pulpy mass in which the seeds are embedded.

*Seed* oblong, oval, or orbicular, variously and obtusely angled, thin, much compressed and more or less flattened on both sides, or turgid or convex on one side and flattened on the other, immersed in pulp, and comparatively large, 6-7 mm. long, 4-5·5 mm. broad, and 1-2 mm. thick in a dried state; testa thin, membranous, pale brown or whitish; hilum and micropyle basal, contiguous.

*Endosperm* copious, horny, almost colourless, and subtransparent.

*Embryo* straight, colourless, about half the length of the seed, but several times narrower; cotyledons rotund-triangular, very obtuse and rounded at the apex, flat or nearly so, closely applied

face to face and thin, lying in the broader plane of the seed and consequently horizontal to the base of the fruit; radicle terete, suddenly narrowed to an obtuse point towards the micropyle and close to the hilum, rather longer than the cotyledons.

**Seedling (fig. 429).**

*Hypocotyl* erect, terete, soon becoming woody, 1·4 cm. above the soil.

*Cotyledons* large, foliaceous, obovate, emarginate, tapering to a narrow subpetiolate base, and clasping the stem between them, about 2·5 cm. long, 1·2 cm. wide.

*Stem* woody, erect, terete, pubescent, afterwards becoming glabrous or nearly so, bright green and afterwards grey when the epidermis becomes torn longitudinally; 1st internode undeveloped; 2nd 2·5 cm. long; 3rd 1·3 cm.; 4th 9 mm.; 5th 1·1 cm.

These lengths vary with the specimen. Another stem measured: 1st internode undeveloped; 2nd 8 mm. long; 3rd 1·6 cm.; 4th 1·65 cm.; 5th 1·25 cm.; 6th 1·6 cm.; 7th 2·2 cm.; 8th 2 cm.; 9th 2·5 cm.

*Leaves* opposite or in whorls of three, frequently undulate, but quite entire, penninerved with alternate, ascending nerves, deep green above and glabrous, but scabrous at the margins and on the midrib, shining, paler beneath and shining, scabrous on the nerves, with a white midrib prominent on both surfaces; petioles very short and thickened at their insertion; tufts of hairs in the axils of the leaves; stipules interpetiolar, closely clasping the stem, and forming a sheath which splits somewhat irregularly on one or two sides. The latter are not very conspicuous, and I see that the artist has unfortunately overlooked them.



FIG. 429.—*Gardenia Thunbergia*.  
Nat. size.

Lower leaves oblanceolate, obtuse, tapering much to the base ; those about the eighth or ninth pair or whorl lanceolate-elliptic, obtuse, undulate at the margin especially in the upper part of the leaf, tapering very much towards the base with straight, even margins.

Ultimate leaves generally in whorls of three, and most frequently one or two are much smaller than the third. Large leaves lanceolate-elliptic, much narrowed to both ends, or broadly elliptic, subrhomboid and suddenly narrowed to both ends, obtuse or acute, deep green and shining, margins much undulated.

***Genipa clusiæfolia*, Griseb. (figs. 480, 481).**

*Fruit* baccate, fleshy, ovoid, with a thick or corky pericarp, and the numerous seeds embedded in pulp.

*Seed* very much flattened and rather thin, suborbicular or variously angled, albuminous ; testa pale brown, thin, subtransparent as well as the endosperm, and showing the outline of the embryo very distinctly when the seed is held up to the light ; raphe forming a black line running round the edge of the seed.

*Embryo* comparatively large,

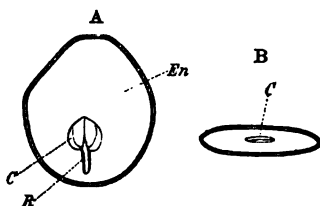
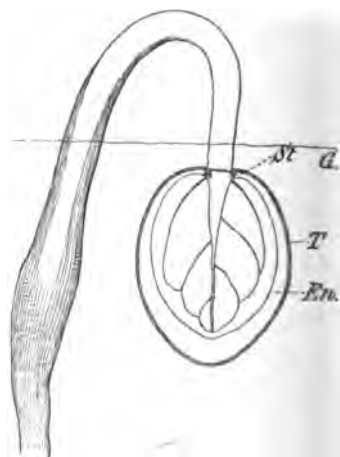


FIG. 480.—*Genipa clusiæfolia*,  $\times 2\frac{1}{2}$ . A, longitudinal section of seed : En, endosperm ; C, cotyledon ; R, radicle. B, transverse section of seed : C, cotyledons.



F G. 481.—*Genipa clusiæfolia*. Germinating seedling with side of seed and one cotyledon removed,  $\times 4$  : En, endosperm ; T, testa ; St, little protuberance covered with unicellular, blunt hairs ; G, ground line.

and about a third the length of the seed, colourless ; cotyledons roundly cordate, closely adpressed to one another, lying in the broader plane of the seed, trinerved with a prominent midrib, situated towards the micropylar end of the seed, surrounded by endosperm, with their basal edges towards the hilum ; radicle about equal to the cotyledons in length, terete, obtuse, slightly stouter where the cotyledons are inserted.



**Seedling (fig. 482).**

*Hypocotyl* erect, terete, minutely scabrous, pale brownish, 1·8-2·4 cm. above the soil.

*Cotyledons* ovate or obovate-elliptic, obtuse, entire, shortly petiolate, tapering into the petiole, trinerved from the base, with the lateral nerves incurved and uniting with the midrib at its apex, with alternate, incurved nerves between, coriaceous, slightly revolute at the margins, glabrous, deep green above, paler beneath, and shining on both surfaces; lamina 1·5-1·65 cm. long, 1-1·2 cm. wide; petiole flattened above, 1-2 mm. long; stipules interpetiolar, united into one ovate, acute piece, colourless and subscarious.

*Stem* erect, terete, ultimately woody, densely pubescent; 1st internode 1-2 mm. long; 2nd shorter.

*Leaves* entire, shortly petiolate or subsessile, decussate, somewhat leathery, bright green and shining above, glabrous,

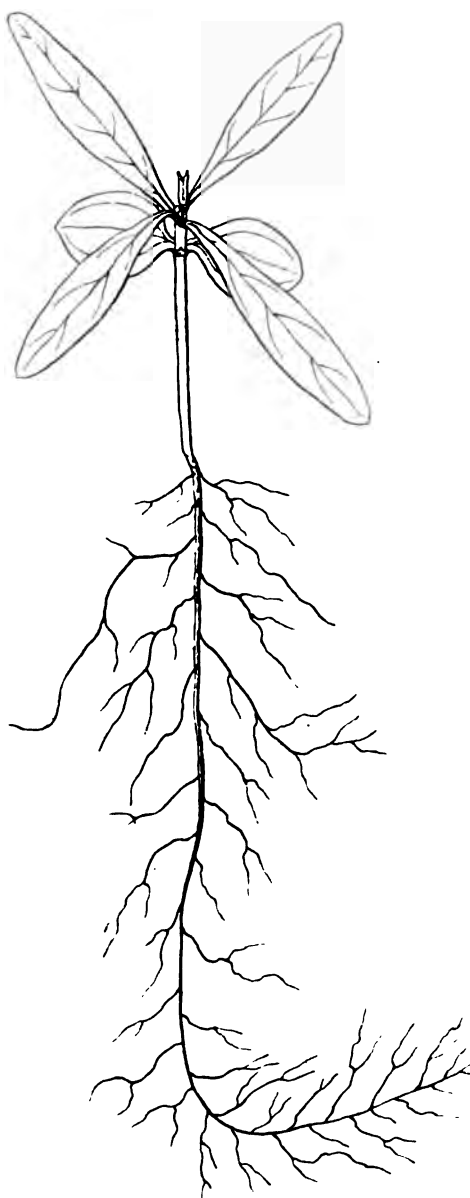


FIG. 482.—*Genipa clusiaefolia*  
Nat. size.

except a band along the margin, appearing reticulate by transmitted light; petioles very short or almost none; stipules interpetiolar, subulate-ovate, acute, the hairs united in one piece, pale brown or grey.

First and second pairs oblong-lanceolate, mucronate, subacute, entire, revolute at the margin.

*Alberta magna*, *E. Mey.* (fig. 433).

*Fruit* two-celled, each cell one-seeded, or sometimes empty, dry, woody, indehiscent, oblong, ten-ribbed, surmounted by the persistent calyx, two to four, generally two, segments of which become greatly enlarged, leaf-like, and coloured (rose in the dry state); enlarged calyx-lobes unequal, trinerved and much reticulated, with the three primary nerves running down the fruit, forming as many ribs to the latter, while the three small calyx-lobes have a prominent midrib, but nearly obsolete lateral ones.

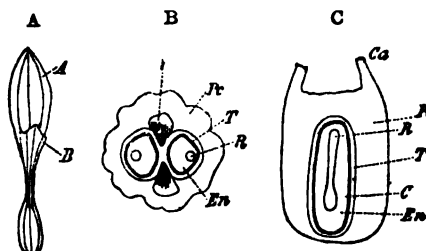


FIG. 433.—*Alberta magna*. A, fruit, nat. size: A and B, two of the calyx-lobes developed into wings; part of B is broken off. B, transverse section of fruit,  $\times 4$ : Pc, pericarp; T, testa; R, radicle of embryo; En, endosperm; V, cavity appearing like an aborted cell in dry fruit. C, longitudinal section of fruit,  $\times 4$ : Ca, calyx; Pc, pericarp; R, radicle; T, testa; C, cotyledon; En, endosperm.

*Seed* oblong, rather slender, conforming to the cavity of the ovary, albuminous; endosperm fleshy, dirty-white, occupying the greater part of the seed; testa thin, adhering to a fleshy layer of the endosperm.

*Embryo* nearly as long as the endosperm, but thin and occupying

only a very small portion of it, straight, colourless; radicle terete, blunt, slightly thickened at the apex, pointing to the upper end of the seed with its tip just within the endosperm, several times longer than the cotyledons, which are shortly and very bluntly ovate, flat, closely adpressed to one another and embedded in the endosperm with their faces to the axis of the fruit, and therefore in the slightly broader plane of the seed.

*Electronia ventosa*, *L.*

*Hypocotyl* erect, terete, glabrous, 2.5–3 cm. long, green.

*Cotyledons* linear-oblong, obtuse, entire, coriaceous, sessile, glabrous, shining green, penninerved like the leaves.

*Stem* erect, terete, hairy, herbaceous; 1st internode 1.5–3 mm. long.

*First leaves* ovate-lanceolate, obtuse, acuminate, shortly petiolate, exstipulate, with a few scattered hairs, shiny green, distinctly and alternately penninerved.

*Ixora parviflora*, Vahl.

*Hypocotyl* very firm, 2.5 cm. long, 1 mm. thick, terete, glabrous, purplish-red.

*Cotyledons* unequal, with connate, rather short petioles, 1.2–1.5 cm. long, and 1.5–1.8 cm. wide; lamina horizontal, obtusely triangular or oblate, cordate at base, very obtuse at apex, entire, palmatinerved, with copious anastomosing veins, glabrous, coriaceous, dark shining green above, paler beneath.

*Stem* very short, pubescent at first, marked with red striæ.

*Leaves* shortly petiolate or subsessile, alternately incurvinerved, coriaceous, evergreen, deep green above, paler beneath; stipules interpetiolar, connate, with a broad base, and an acute, more or less acuminate point.

First pair subsessile, 1–1.5 cm. long, and about 6 mm. wide, spatulate-obovate, penninerved.

Second pair remaining very minute for a long time after the unfolding of the first.

*Ixora congesta*, Roxb. (fig. 484).

*Ovary* two-celled, two-ovuled; ovules peltate, amphitropous; micropyle inferior.

*Fruit* baccate, subdidymous when both carpels are fertilised and come to maturity, but globose if only one is fertilised and perfect, glabrous, one- to two-celled and one- to two-seeded; endocarp hard

and tough, convex or rounded dorsally, concave with an orbicular ventral orifice, pale brown, marked with darker spots; mesocarp fleshy; epicarp dark purple or black.

*Seed* conforming to the endocarp, rounded on the back, deeply concave on the ventral aspect at its insertion on the placenta, and peltate, glabrous; testa thin, membranous; hilum forming a large

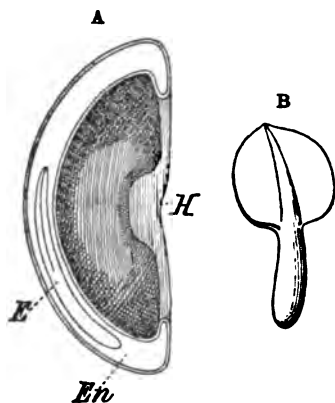


FIG. 484.—*Ixora congesta*. A, longitudinal section of seed,  $\times 8$ : E, embryo; En, endosperm; H, hilum. B, embryo,  $\times 8$ .

peltate disc, covering over the concavity of the seed; micropyle inferior.

*Endosperm* copious, cartilaginous and very hard when dry.

*Embryo* central in the endosperm, curved longitudinally and also transversely in conformity with the shape of the seed; cotyledons triangular-ovate, obtuse, entire, thin; radicle cylindrical, obtuse, pointing to the micropyle at the lower side of the hilum, longer than the cotyledons.

***Pavetta madagascariensis*, ? Auct. (fig. 485).**

*Hypocotyl* woody, erect, terete, glabrous, scabrous, pale green, 1-1.5 cm. above the soil.



FIG. 485.—*Pavetta madagascariensis*.  
Nat. size.

*Cotyledons* semiorbicular or oblate, entire, glabrous, shining, coriaceous, horizontal, petiolate, penninerved; lamina 1.1 cm. long, 1.5 cm. wide; petiole 2 mm. long, flattened above, convex beneath; stipules short, triangular, acute, interpetiolar.

*Stem* woody, erect, terete, pubescent, scabrous, green; 1st internode 6 mm. long; 2nd 3 mm.

*Leaves* entire, glabrous, shining, deep green above, paler beneath, alternately penninerved, coriaceous; stipules interpetiolar, ovate, acute, connate in one piece.

First and second pairs elliptic-oblong, obtuse.

In *Pavetta speciosa* the cotyledons are rotund-cuneate; lamina 1 cm. long, 1.1 cm. wide.

***Coffea arabica*, L. (fig. 486).**

*Primary root* a long taproot, woody, with a great many branched, greyish, fibrous lateral rootlets.

*Hypocotyl* woody after a time, about 6 cm. long, 2-3 mm. thick, round, with a greyish-brown coriaceous rind bursting open in broad longitudinal fissures, and showing the green layer below.

*Cotyledons* sessile, frequently three in number, about 3.5 cm. long, 4.5 cm. wide, oblate, apex obtuse, margin sinuate, with five sunk nerves and distinctly reticulate, coriaceous, glabrous and shining on both sides, dark green above, paler beneath.

*Stem*.—1st and 2nd internodes 2 cm. long, resembling the hypocotyl.

*Leaves* entire, lanceolate-elliptic, alternately incurvinerved and reticulate, glabrous, evergreen, subcoriaceous, deep green above, paler beneath; petioles very short, flattened above; stipules interpetiolar, connate, very persistent, with a broad base and one or both tips free and more or less acuminate, closely applied to the stem.

***Morinda tinctoria*,**  
*Roxb.*

*Hypocotyl* erect, flattened, glabrous, short, about 5 mm. long, light green or almost colourless.

*Cotyledons* obtusely ovate, glabrous, shortly petiolate, about 1.5 cm. long by 1 cm. wide, dull green, entire; midrib with numerous ascending veinlets, as in the leaves.

*Stem* herbaceous, erect, quadrangular, ultimately woody, glabrous, light green; 1st internode 1–2 mm. long.

*Leaves* entire, linear, acute, shortly petiolate or sessile, with connate interpetiolar stipules, glabrous, dark green above, lighter below; midrib prominent with ascending veinlets.

***Psychotria* sp. (fig. 487).**

*Primary root* long, tapering, much branched.

*Hypocotyl* erect, terete, 2.5–3.5 cm. long, glabrous.

*Cotyledons* broadly ovate, obtuse, petiolate, alternately incurvinerved, somewhat coriaceous, glabrous, shining, stipulate; lamina 9–12 mm. long, 9–11 mm. wide at the base; petiole flattened above, 3 mm. long; stipules interpetiolar and united so as to form one ovate,

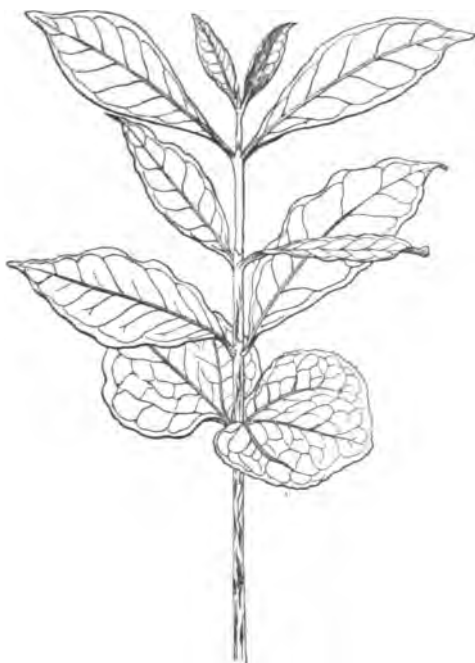


FIG. 486.—*Coffea arabica*. Half nat. size.

acuminate piece between each petiole, soon becoming dry, brown, and scarious.

*Stem* erect, and in the seedling stage at least having ridges running downwards from the base of the interpetiolar stipules.

*Leaves* opposite, decussate, alternately incurvinerved, subcoriaceous, shining, deep green above, paler beneath, shortly petiolate ; stipules interpetiolar, subscarious.

First and second pairs of leaves ovate, obtuse, entire.

***Rubia cordifolia*, L. (fig. 438).**

*Primary root* tapering downwards, flexuose, with numerous lateral rootlets, orange-red.

*Hypocotyl* erect, terete, glabrous, minutely scaberulous, yellowish, 3-3.5 cm. long.

*Cotyledons* ovate, obtuse, entire, trinerved from the base or sometimes five-nerved, with the two stronger laterals incurved and uniting with the midrib near the apex of the lamina, reticulate, glabrous, petiolate, light green or stained with dull red ; lamina 1.4-1.65 cm. long, 9-10.5 mm. wide ; petiole semiterete, channelled above, minutely pubescent at the edges, or scaberulous, glandular at the base and slightly connate, 4-5 mm. long.

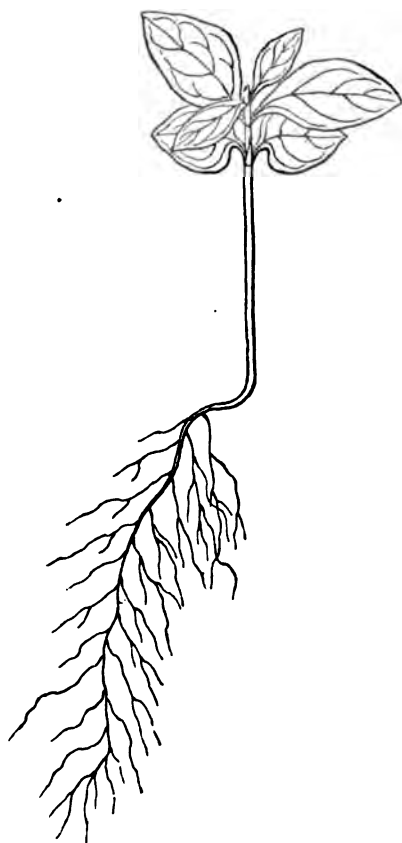


FIG 437.—*Psychotria* sp. Nat. size.

*Stem* erect in the seedling stage, ultimately climbing, herbaceous, rather acutely quadrangular, with transparent cartilaginous edges, glabrous, shining, green ; 1st internode 2-2.5 cm. long.

*Leaves* opposite (described in 'Genera Plantarum' as in whorls of four, rarely six), three- to five-nerved like the cotyledons, ob-

scurely reticulate, thinly pubescent above, with short hairs directed towards the apex, less so beneath, and glabrescent when old stipules similar to the leaves but smaller, at least in the early stage; petioles short, semiterete, slightly tapered upwards, channelled on the upper side, slightly scaberulous with short hairs, and an interpetiolar transverse line of hairs or small bristles.

First pair of leaves ovate, obtuse, cordate at the base, three- or less distinctly five-nerved; stipules similar but much narrower and less distinctly nerved, petiolate, cordate at the base.

*Galium Aparine*, L. (figs. 439, 440).

*Fruit* didymous, densely covered with hooked prickles, indehiscent, falling away in two separate pieces.

*Seed* subglobose, ventrally attached and peltate, with a deep round hollow on the ventral aspect caused by the indentation of the testa, dark brown or black, finely reticulate; raphe ventral in the interior of the cavity; radicle inferior, close to the edge of the cavity.

*Endosperm* copious, pale subtransparent white, horny.

*Embryo* curved and reaching from the micropyle near the outer edge of the ventral cavity for about three-quarters the distance to the other side, colourless, embedded in the endosperm; cotyledons oblong-ovate, obtuse, emarginate, covered on the upper surface with clear colourless or crystalline points or prickles directed towards the apex, trinerved at the base with stronger lateral nerves upwards, all of which are incurved, the basal ones uniting with those above them, which then converge and unite in the apical sinus.

During germination the endosperm is absorbed, and the cotyledons increasing at the same time fill the internal cavity of the seed; the radicle pushes its way into the soil where it throws out lateral rootlets; the hypocotyl is the first to appear above ground and pulls the now largely developed cotyledons out of the soil, without the testa if the seed is buried sufficiently deep, otherwise the testa is carried up on their tips. The cotyledons were folded over the large indented process of the pericarp, and are thus necessarily concave, the emarginate apex abuts on the upper side of the same indentation, and they are undulated or crisped in the middle owing to the resistance at their apex and base. The testa

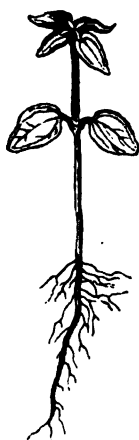


FIG. 438.  
*Rubia cordifolia*.  
Half nat. size.

and pericarp at the latter place finally give way and the cotyledons are drawn out.

*Galium saccharatum*, All. (fig. 441).

*Fruit* deeply bilobed, almost separated into two pieces, two-

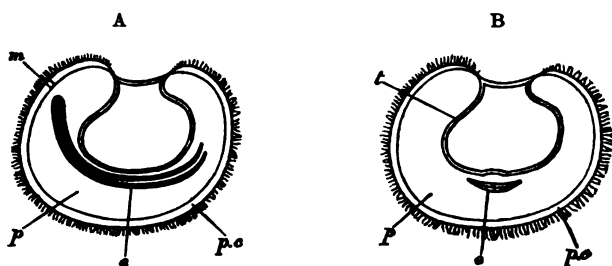


FIG. 439.—*Galium Aparine*. A, longitudinal section of seed,  $\times 8$ : m, micropyle; t, testa; pc, pericarp; e, embryo; p, endosperm. B, transverse section,  $\times 8$ .

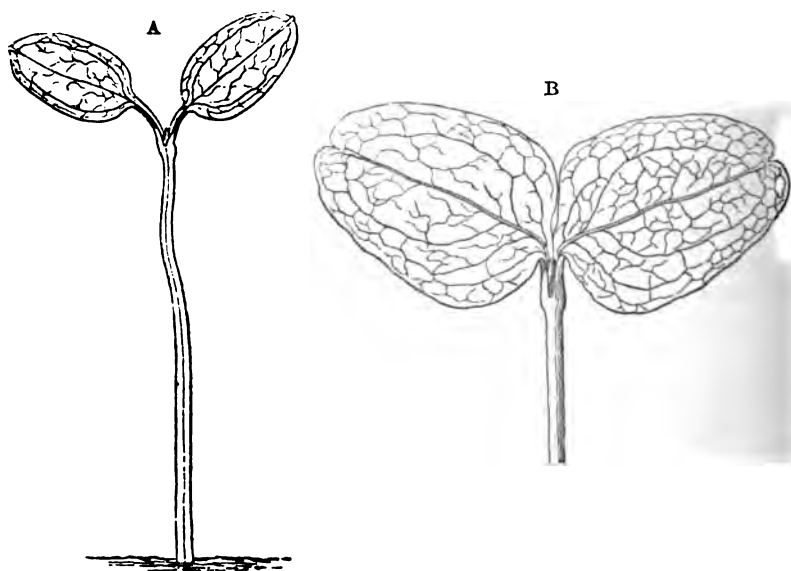


FIG. 440.—*Galium Aparine*,  $\times 2$ . A, young seedling. B, the same, a few days older. (Bleached to show venation.)

celled, two-seeded, indehiscent; pericarp densely covered with corky tubercles.

*Seed* adhering to the pericarp, convex on the back, deeply



hollowed on the ventral aspect; testa thin, membranous; hilum on the middle of the concave ventral aspect.

*Endosperm* abundant, horny.

*Embryo* curved, following the convexity of the hollow with the greater part of the endosperm towards the periphery, and only a thin layer between it and the inner or ventral aspect of the seed, colourless, and three-quarters the length of the seed; cotyledons linear, obtuse; radicle inferior, curved round nearly but not quite to the edge of the concavity.

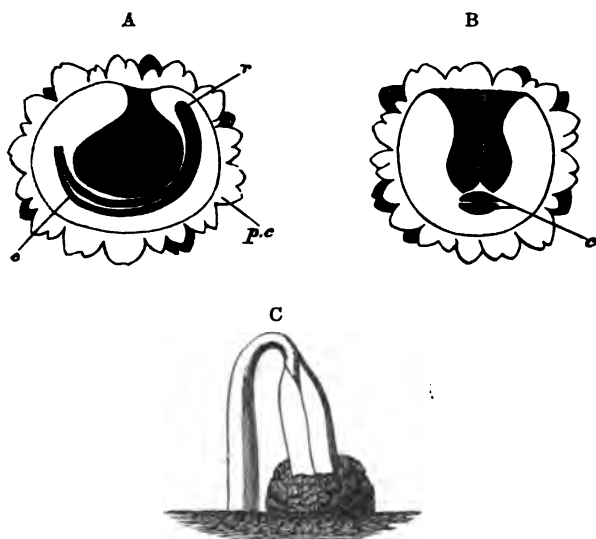


FIG. 441.—*Galium saccharatum*. A, longitudinal section of seed,  $\times 8$ : c, cotyledons; r, radicle. B, transverse section of seed,  $\times 8$ : c, cotyledons. C, germinating seedling,  $\times 4$ .

### Seedling (fig. 442).

*Primary root* long, tapering, fibrous, annual, yellow with reddish lateral rootlets.

*Hypocotyl* erect, terete, scabrid with short deflexed prickles, pale green, about 1.85 cm. long.

*Cotyledons* linear, obtuse, minutely emarginate, margin with minute deflexed prickles, surface glabrous, tapered to the base, 2.1 cm. long, 4 mm. wide. Three to five buds are ultimately developed in the axils of the cotyledons.

*Stem* herbaceous, annual, erect, ultimately climbing by means of the minute prickles, quadrangular, with minute deflexed prickles

on the angles, swollen at the nodes; 1st internode 1.6 cm. long; 2nd 5 mm.

*Leaves* opposite or verticillate, narrowed to a short petiole, ciliate at the margin with minute prickles directed towards the apex,

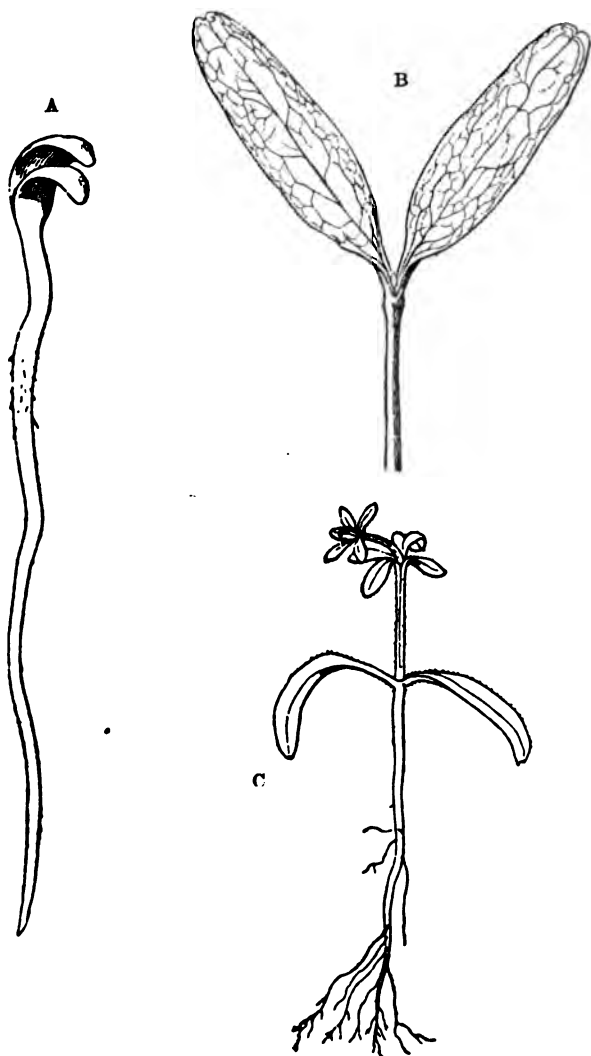


FIG. 442.—*Galium saccharatum*. Seedlings in three stages: A, very young,  $\times 4$ ; B, cotyledons from a slightly older seedling,  $\times 2$  (bleached to show venation); C, older seedling, nat. size.

light rather opaque green; petioles very short, channelled above, subcarinate beneath; stipules interpetiolar, similar to the leaves in every respect, but smaller in the seedling stage.

First pair oblanceolate, cuspidate, channelled above, with the midrib prominent beneath; stipules interpetiolar and single between the leaves.

Second pair decussating with the first and similar; stipules similar to the leaves, two on one side of the stem and one on the other, making in all with the leaves five.

Third pair ditto, but sometimes with all the four stipules developed.

Fourth pair with the four stipules present.

*Galium tenuissimum*, *M. Bieb.*

*Primary root* similar to that of the last species.

*Hypocotyl* erect, tapering insensibly into the root, green above soil, glabrous.

*Cotyledons* ovate, obtuse, entire, with one median nerve shortly petiolate, glabrous; lamina 2.75 mm. long, 2 mm. wide; petiole flattened above, about 1 mm. long.

*Stem* annual, erect, quadrangular, glabrous or with a few minute scattered prickles on the angles; 1st internode 5 mm. long; 2nd 5.5 mm.; 3rd 7 mm.

*Leaves* opposite and verticillate, with large interpetiolar foliaceous stipules, shortly petiolate, glabrous or with a few minute scattered prickles on the upper surface and margin, acute or apiculate, one-nerved only in seedling stage; stipules exactly similar to the leaves but smaller (at least in the seedling).

First whorl of two leaves and two stipules, obovate or subelliptic, shortly petiolate.

Second whorl similar, the larger members (leaves) decussating with those below them.

Third whorl of two leaves and four stipules.

*Crucianella ægyptiaca*, *L.* (fig. 448).

*Primary root* long, wiry, tapering, flexuose, brownish-red, with short lateral fibres, annual.

*Hypocotyl* erect, terete, very short, tapering indistinguishably into the root, scaberulous.

*Cotyledons* ovate, obtuse, emarginate, shortly petiolate, with a distinct midrib, and one to two alternate, ascending, incurved nerves on each side, but difficultly discernible in the fresh state, glabrous, dull deep green above, paler beneath; lamina 4.5-5.5 mm. long,

2.75–3.25 mm. wide; petiole broad, dilated and subconnate at the base, 1–1.25 mm. long.

*Stem* herbaceous, annual, erect, quadrangular, angles prominent, acute, scaberulous with decurved hard points or prickles, glaucous-green, minutely dotted with pale-coloured markings, otherwise glabrous, thickened at the nodes; 1st internode 3.5–4 mm. long; 2nd 9–11 mm.; 3rd 1.9–2.2 cm.

*Leaves* opposite, decussate or with the stipules appearing verticillate, sessile, with a distinct midrib prominent on the under side, but no other discernible venation in the fresh state, scabrous and deep green above, glabrous, and paler beneath with a cartilaginous, revolute margin, connate and together with the stipules forming a little cup round the stem; stipules one between each pair of leaves, subulate or linear-subulate, acute, revolute at the margin, similar in venation and other respects to the leaves but generally shorter, with their midribs as in the case of the leaves continuous with the angles of the stem, interpetiolar and connate.

First pairs of leaves lanceolate, longer and much broader than the stipules.

Second to fifth pairs linear-subulate, acute, similar to the stipules but slightly longer.

*Sherardia arvensis*, L. (fig. 444).

*Primary root* long, slender, tapering, with numerous lateral fibres, all bright red.

*Hypocotyl* bent or procumbent, suddenly tapering downwards, glabrous, pale green, 7 mm. long.

*Cotyledons* large, foliaceous, fleshy, rotund, minutely emarginate, scabrous at the margin and minutely so all over the

upper surface, trinerved and indistinctly reticulate, with the lateral nerves incurved and uniting with the midrib near the apex; lamina 9 mm. long, 8 mm. wide; petiole short, flattened above and



FIG. 443.  
*Crucianella aegyptiaca*.  
Nat. size.

shallowly grooved, often both directed to the upper side of the procumbent stem, so that the cotyledons may be fully exposed to light, about 1.5 mm. long.

*Stem* herbaceous, annual, procumbent, quadrangular; angles obtuse, smooth, glabrous, but in the adult state with deflexed prickles and pubescent; pale green; 1st internode 1 cm. long; 2nd 6.5 mm.

*Leaves* scabrously hairy on both surfaces, subfleshy in the seedling, light or dark green; petioles short, shallowly grooved above; stipules interpetiolar, foliaceous, equal to or smaller than the leaves and similar to them in most particulars.

First pair obovate, rounded, cuspidate; stipules similar, slightly smaller, one on each side of the stem, at all events in the first three pairs of leaves.

Second and third pairs similar, with stipules nearly the size of the leaves.

Ultimate leaves in pairs, lanceolate, acute, hairy on both surfaces; stipules four, similar and about the same size as the leaves, and revolute at the margin as are the leaves, especially when dry.

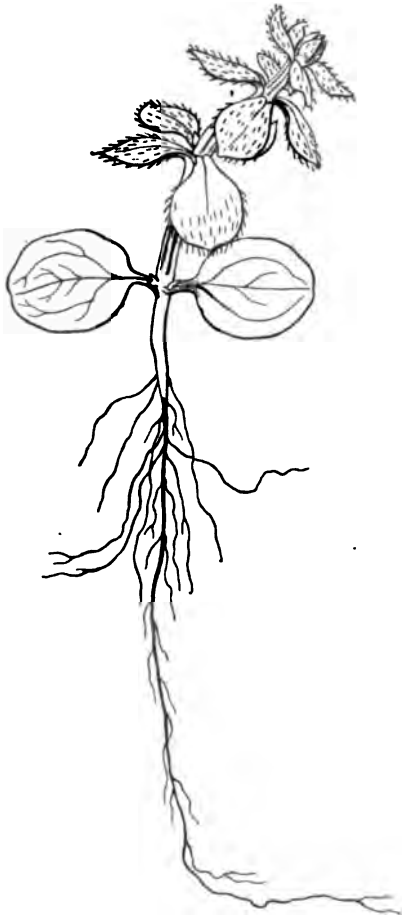


FIG. 444.—*Sherardia arvensis*  $\times 2$ .

## VALERIANEÆ.

Benth. et Hook. *Gen. Pl.* ii. 151.

*Fruit and Seed.*—As in the Compositæ, with which this Order has much affinity, the ovary is inferior, but it is three- instead of one-celled. One of the cells is perfect while the other two may be fertile or empty and represented by slender ribs which are sometimes appendiculate on one side. There is a solitary pendulous anatropous ovule in each fertile cell. The fruit is an inferior achene crowned by a many-rayed pappus-like calyx, or the latter is represented by a few-lobed cupular crown or minute inconspicuous teeth. The empty cells during the growth of the fruit remain unchanged or become drawn out upon one side. The solitary seed is comparatively large, conforming to the fertile cell of the fruit ; and has a thin membranous testa. Endosperm is generally wanting, or reduced to a thin stratum. The embryo conforms in outline to that of the seed, and is straight with oblong cotyledons, and a rather elongated superior radicle. A very characteristic type of the Order is represented by *Valeriana officinalis*. The ovate, dorso-ventrally compressed fruit has only one fertile cell which is wholly occupied by the seed. It is surmounted by a many-rayed feathery pappus-like calyx, the segments of which are united at the base, forming a little cup which readily becomes disarticulated from the mature achene. The embryo conforms to the interior of the seed, but is nevertheless surrounded by a thin stratum of endosperm, and has plano-convex cotyledons. The fruit of *Valerianella coronata* is surmounted by a five- to six-lobed, cup-like calyx ; but the segments are not feathery. That of *V. Auricula* is naked or furnished with very small teeth only.

*Seedlings.*—There is comparatively little variation in the form of the seed and embryo, so that the cotyledons seem to be pretty constant throughout the Order. They are shortly and broadly oblong, emarginate, petiolate, and trinerved. *Valeriana officinalis* may be regarded as typical as far as the

cotyledons are concerned. The first leaf is rotund, slightly cordate at the base, and obtusely angled. The second is larger, five-nerved and dentate. The ultimate leaves are opposite and pinnatisect. The cotyledons of *Centranthus macrosiphon* (fig. 445) are broader and relatively shorter. The first five pairs of leaves are broadly ovate, serrate-dentate, and the ultimate ones scarcely differ. The first pair of *Patrinia rupestris* are spatulate, obtuse, and entire, while succeeding ones vary from lanceolate to elliptic, and are bluntly serrate.

The germinating seedling of *Valerianella coronata* (fig. 446) shows a remarkable contrivance for fixing the fruit or achene to the soil while the embryo makes its escape. The embryo swells up and bursts through the side of the fruit beneath the calyx-limb; then the radicle pierces through the latter, entering by the outer face and pushing through both sides enters the ground, thus pinning the fruit to the soil, while the cotyledons are pulled out in a comparatively short time and spread out to the light. At this stage they are shortly oblong, entire and sessile.

#### *Valeriana officinalis*, L.

*Fruit* an inferior achene, ovate, dorso-ventrally compressed, crowned with a conspicuous feathery, pappus-like calyx, which is articulated with the achene, one-nerved on the back and trinerved on the face; the two lateral nerves are filiform, and represent the two aborted cells.

*Seed* narrowly obovate, pendulous from the top of the cavity of the fertile cell, dorsally compressed, and otherwise conforming to the interior of the cell; hilum basal at the upper end of the seed; micropyle close to the hilum and superior; chalaza inconspicuous, apical.

*Endosperm* forming a thin film, surrounding the embryo, white.

*Embryo* straight, large, colourless, more or less filling the seed, and conforming to it in outline; cotyledons obovate-oblong, rounded at the apex, entire, tapering at the base; radicle short, stout, obtuse.

#### *Seedling.*

*Primary root* tapering, slender, fibrous.

*Hypocotyl* very short, terete, glabrous, 1.5 mm. long.

*Cotyledons* rotund or oblong, short, emarginate, petiolate, trinerved from the base and alternately penninerved upwards, glabrous, light green; lamina 5-1 cm. long, 5-7 mm. wide; petiole rather broad, grooved above, dilated at the base and clasping, 8-11 mm. long.

*Stem* herbaceous, perennial portion very short; elongated when about to flower.

*Leaves* simple, radical and cauline, opposite (primary ones alternate), exstipulate, petiolate, glabrous in seedling, thinly hairy in the adult; petioles grooved above, semiterete, dilated and sheathing at the base.

No. 1. Rotund, subcordate at the base, slightly angled, but not cut, five-nerved at the base and suboppositely nerved upwards.

No. 2. Rotund, obtuse, cordate and five-nerved at the base, dentate with the nerves ending directly in the teeth.

Ultimate leaves ovate, or subtriangular in outline, pinnatisect, often unequal-sided, thinly hairy; segments alternate or sometimes opposite, frequently unequal on opposite sides of the midrib, lanceolate, obtuse, much narrowed at the base, coarsely, obtusely and irregularly serrate, three- to five-nerved longitudinally from the base, strongly reticulate with nerves sunk on the upper surface and prominent beneath.

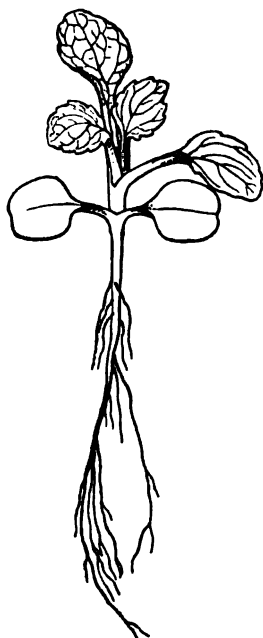


FIG. 445.

*Centranthus macrosiphon*.  
Nat. size.

*Centranthus macrosiphon*, Boiss. (fig. 445).

*Primary root* stout, tapering, with fibrous lateral rootlets.

*Hypocotyl* mostly subterranean, pale or colourless, glabrous, terete, passing insensibly into the root.

*Cotyledons* broadly ovate and truncate, emarginate, or almost square, petiolate, glabrous, one-nerved; lamina 7.5 mm. long, 7 mm. wide; petiole convex on the back, channelled above, about 6 mm. long.

*Stem* annual, developed when about to flower.

*Leaves* simple, radical and cauline, opposite, decussate, glabrous, alternately or suboppositely incurvinerved, reticulate, deep green;



petioles ridged or subcarinate beneath, rather acutely channelled above, dilated towards the base and subperfoliate.

First pair broadly ovate, obtuse, crenate.

Second pair ovate or oval, dentate.

Third, fourth, and fifth pairs broadly ovate, obtuse, more or less deeply, irregularly, obtusely, and mucronately dentate.

*Valerianella coronata*, DC. (fig. 446).

The radicle in germination usually bursts through the side of the fruit, and then pierces the limb of the calyx, thus fixing the fruit in the soil, as happens also in *Scabiosa*.

When free and above soil the cotyledons are shortly oblong, obtuse, entire, sessile and glabrous. One embryo only out of twenty-eight made its exit at the apex of the fruit, and from the centre of the calyx-limb. The radicle in this case pierced the calyx from its inner face outwards, and not from the outer face inwards, as is the usual method.

The fact of the radicle bursting through the side of the fruit is accounted for by two of the three cells of the ovary being small and empty, the third containing a seed is accordingly excentric, and therefore in germination its radicle naturally pushes through one side of the fruit.

*Valerianella Auricula*, DC.

When the fruits have been moderately well covered with soil the embryo in most cases gets clear out of the fruit simply by the elongation of the hypocotyl.

The cotyledons are shortly oblong, obtuse, minutely emarginate otherwise entire, sessile, convex above, concave beneath, glabrous, light green.

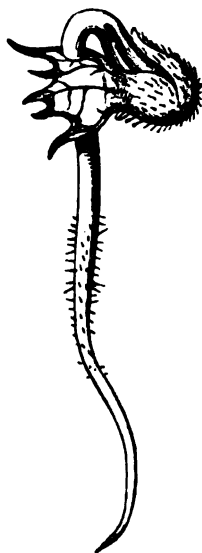


FIG. 446.—*Valerianella coronata*,  $\times 4$ .  
Germination.

## DIPSACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 157.

*Fruit and Seed.*—The ovary of the Dipsacæ is simple, inferior and one-celled, with a solitary, pendulous, anatropous ovule; but in addition to the true calyx with which it is surmounted, each flower of the capitulum is surrounded by an involucl which completely encloses it, and appears like a second or a double calyx. The fruit is an achene surmounted by the persistent rarely deciduous calyx, and is completely enclosed by the involucl, also persistent and either surmounted by a lamina varying greatly in size, or truncate at the apex. The solitary seed, suspended from the apex of the cell, is covered by a thin membranous testa, and contains a thin or thick stratum of fleshy endosperm. The embryo is straight with a superior radicle and oblong or ovate cotyledons.

The pendulous anatropous ovule characteristic of the Order is represented by a vertical section of the ovary of *Scabiosa atropurpurea* (fig. 454, A) just after the expansion of the flower. For comparison with this Order the erect anatropous ovule of the Compositæ is represented in the two kinds of flowers of *Chrysanthemum coronarium* (fig. 454, B, C).

The reason for the ovule of the Dipsacæ being pendulous and anatropous with a superior radicle has reference perhaps to the exit of the embryo during germination. The involucl is often or always more thickened and coriaceous, and often contracted at the base, making egress there difficult or impossible. The pericarp is thin and easily ruptured at the apex, or is actually open in cases where the calyx is deciduous. This idea is supported by the structure of the fruits in the following species, namely, *Scabiosa palæstina* (fig. 451), *S. atropurpurea* (fig. 454), *S. australis* (fig. 449), *S. Gramuntia* (fig. 453), *S. graminifolia*, *S. Columbaria*, *S. Parnassi*, *S. arvensis*, and *S. caucasica* (fig. 455); also by *Cephalaria leucantha*, *C. rigida*, *Dipsacus sylvestris*, *D. ferox*, and *D. inermis*.

A fruit with the calyx deciduous is represented by *Dipsacus*

*sylvestris* with a characteristic embryo. *Scabiosa australis* (fig. 449) has a small funnel-shaped four-toothed calyx-limb, and its embryo is similar to that of *Dipsacus sylvestris*, but the seed contains a larger quantity of endosperm. The embryo of *Scabiosa palæstina* has broadly ovate cotyledons nearly dividing the endosperm into two equal portions. The fruit (fig. 451) is also notable both for the long slender beak into which it is prolonged at the apex, and the ten to twelve long, slender, feathery rays of the calyx. The involucl is also one of the most highly developed in the Order; its tube has eight strong ribs alternating with as many membranous portions actually perforated in the upper part; and the lamina is broadly expanded, flat or nearly so, membranous, and traversed by numerous nerves, excurrent as small teeth along the margin. The lower coriaceous portion would protect the seeds against drought, while the membranous lamina would serve to disperse the fruit.

*Seedlings*.—The structure and shape of the fruit and seed in this Order are very constant, varying chiefly in size, and so are the cotyledons as far as they have come under my observation. The prevailing form is broadly oblong, entire or emarginate, sessile, or tapering into a short broad petiole, and trinerved, but the lateral nerves are often indistinct. Most of them are narrow and linear or oblong when they emerge from the seed, but they generally increase considerably in size and sometimes undergo a little modification after germination by becoming emarginate, oblong-oval, somewhat obovate, or almost spatulate owing to their tapering into a broad petiole.

The involucl surrounding the fruit on the contrary varies considerably, and, together with the different modes of germination, offers a ready means of classifying most of the seedlings observed. The involucl of *Dipsacus sylvestris* is truncate at the apex, and the fruit crowned by a deciduous calyx. The seedling (fig. 447) has oval-oblong cotyledons, and the first six leaves are spatulate and crenate. *D. ferox* is another type of this group, but its mode of germination (fig. 448) is not common to all the species. The seedlings nearly always carry up the seed, fruit, and involucl on the

tips of the cotyledons, which are rather broad and burst their investments during germination. Those of *Scabiosa australis* are linear-oblong, and do not burst the fruit and involucrel during germination (fig. 449), and if the latter are fairly well covered with soil they are left in the ground when the embryo makes its exit. The cotyledons ultimately become broadly oblong and distinctly emarginate. The two primary leaves are broadly oval, and shortly petiolate (fig. 450). The fruit and involucrel of this species closely resemble those of *Dipsacus ferox*, and its different behaviour during germination is accounted for by the fact that there is a small tooth-like projection on one side of the base of the hypocotyl (fig. 449, B), and this, fixing itself in the small rim or lamina of the involucrel, holds it down while the cotyledons are drawn out.

A second distinct type is represented by *Scabiosa Gramuntia* (fig. 453). The involucrel has a well-developed cup-like lamina, and the radicle on germination pierces it, and holds it firmly to the soil by means of a thickening at the base of the hypocotyl while the latter on lengthening draws out the cotyledons. This thickening is symmetrical or equal all round, not unilateral as in *S. australis*. The fruit of *S. Columbaria* is rather thicker and shorter, while the cotyledons are also shorter, but in no other respect do they or the germinating seedling differ from *S. Gramuntia*.

In the third type the radicle of the germinating seedling pushes through the sides of the involucrel, beneath the thickened rim at the base of the lamina. The base of the hypocotyl also has a symmetrical, annular thickening as in the second group. The involucrel of *Scabiosa palæstina* (fig. 451) is salver-shaped and attains a much greater size than that of any other species observed. The lamina is particularly large, membranous and traversed by straight radiating nerves excurrent at the margin, forming a deeply fringed border. Beneath the thickened rim at the base of the lamina are numerous perforations, through one of which the radicle finds its way, fixing the fruit to the ground. The cotyledons ultimately become obovate-spathulate and slightly emarginate. *S. graminifolia* has likewise a perforated involucrel. The thickening of the hypocotyl is well shown by *S. atropurpurea*

(fig. 454, D). The cotyledons are oval-oblong and shortly petiolate. The first four pairs of leaves vary from spatulate to oblong or elliptic, while the fifth to the seventh pairs inclusive are pinnatipartite. The lamina of the involucl is smaller than in *S. palæstina*, but there are no perforations in any part of it. The radicle easily pushes its way through the membranous portions at the sides between the greatly thickened ribs of the involucl, thus demonstrating the economy of the unequal thickening. A peculiar anomaly presents itself in the germinating seedling of *Scabiosa caucasica* (fig. 455). The base of the hypocotyl is more or less thickened as in the other species, but it generally if not always pushes itself right through one or other of the membranous portions of the involucl, and the thickening appears therefore to be now functionless so far as its original purpose is concerned. The lamina of the involucl is reduced to a rim crowned by numerous coarse bristle-like segments. The seedling is different from all others I have noticed. The hypocotyl remains short, the oblong entire cotyledons are sessile, and the first pair of leaves are oblanceolate and entire. The radical leaves of the adult plant are spatulate, entire and decurrent upon the long petiole, but most of the cauline ones are pinnatisect with linear segments.

The seedlings of *S. rutæfolia* (fig. 456) exhibit a similar evolution of the foliage to *S. atropurpurea*, but I have not seen either the fruit or germination. Furthermore the seedlings are dimorphic; some have opposite leaves with the first three pairs spatulate and bluntly serrated near the apex, and the fourth pair more or less lobed, while others have the leaves in whorls of three. Those of the first three whorls resemble the leaves of the first type, but in the fourth and fifth whorls they are irregularly and deeply pinnatifid. The cotyledons of *S. maritima* are obovate-oblong and emarginate, while the first pair of leaves are oval or obovate.

It will be noticed that in all of the above-mentioned seedlings the cotyledons are sessile on leaving the seed, but afterwards petiolate, *Scabiosa caucasica* alone forming an exception.

***Dipsacus sylvestris*, L.**

*Fruit* an achene enclosed in a tetragonal involucl, having an intermediate set of smaller ridges, one on each face, free from the

involucel, oblong, apex conical, base obtuse, crowned with the ultimately deciduous calyx and marked longitudinally with eight ridges; pericarp extremely thin and membranous except on the ridges.

*Seed* oblong, conical at the tip, conforming to the outline of the ovary, which it completely fills; testa extremely thin and membranous; hilum at the extreme upper end of the seed and inconspicuous.

*Endosperm* copious, fleshy, white, surrounding the embryo.

*Embryo* straight, large, nearly equal in length to the seed; cotyledons oblong, obtuse, entire, plano-convex, embedded in the endosperm which is thinnest at the edges of the cotyledons and the radicle; radicle very stout, slightly and suddenly narrowed at the tip which is close to the apex of the seed, about one-third as long as the cotyledons.



FIG. 447.—*Dipsacus sylvestris*.  
Half nat. size.

#### Seedling (fig. 447).

*Primary root* stout, long, tapering, with numerous lateral fibres, biennial.

*Hypocotyl* subterranean, stout, colourless, about 1 cm. long.

*Cotyledons* subfoliaceous, glabrous, petiolate; lamina oval-oblong, entire or minutely emarginate, 12 mm. long, 7 mm. wide; petiole flattened, 7 mm. long.

*Stem* herbaceous, erect, and elongating the second year when about to flower.

*Leaves* simple, radical and ultimately cauline, opposite, exstipulate, radical ones petiolate, cauline sessile, and connate by their bases, hairy on both sides, pale green, nerved and reticulate with ascending and sub-incurved nerves, entire or toothed; petioles rather broad, channelled, slightly winged upwards.

First pair spatulate, obtuse, subentire or shallowly and obsoletely crenate.

Second pair similar, shallowly crenate with long petioles.

Third pair oblong-spatulate, obtuse, shallowly crenate, decurrent on the long petioles.

Ultimate leaves cauline, sessile, connate by their broad bases, oblong-lanceolate, obtuse, irregularly and obtusely toothed except at the base and tip, penninerved with numerous subparallel nerves, glabrous, spiny along the midrib beneath with recurved prickles; teeth deepest and coarsest about the middle of the leaf.

*Dipsacus ferox*, *Lois.* (fig. 448).

*Germination.*—The radicle emerges at the apex of the fruit through the mouth of the involucl. Numerous root-hairs are produced on the radicle and the base of the hypocotyl.

The fruit enclosed in the involucl is then usually carried up with the cotyledons (fig. 448), which by widening have split the involucl along one side (about the second day after their first appearance above ground).

Whether the fruit and involucl are carried up or not, the energy of the expanding cotyledons is generally, if not always, able to extricate them from such investments, and the cotyledons spread out to the light.<sup>1</sup> They are oblong, obtuse, entire with a slightly prominent, apical, colourless tooth, narrowed into a short petiole, with a few alternate, ascending, obscure, lateral nerves, glabrous, pale green but soon becoming deep green. Hypocotyl glabrous.



FIG. 448.—*Dipsacus ferox*. The fruit enclosed in the involucl carried up by the cotyledons in germination,  $\times 8$ . (Second day after first appearance above ground.)

*Scabiosa australis*, *Wulf.*

*Achene* conical-oblong, terminated by the small funnel-shaped, four-toothed lamina of the calyx, and surrounded by an involucl, thin-walled, membranous, ribbed, glabrous; involucl flask-shaped, with a narrow neck and funnel-shaped mouth, strongly eight-ribbed, with the ribs obtuse and the alternate ones smaller, remaining as a covering to the fruit till its germination and decay.

*Seed* oblong, obtuse at the lower end, narrowed to a short obtuse point at the upper end, closely conforming to the interior of the achene; hilum and micropyle superior, contiguous; testa thin, membranous, very pale-coloured; chalaza apical and inferior.

*Endosperm* copious, fleshy, white when moist.

<sup>1</sup> Ninety-eight to a hundred per cent. of the seedlings carry up the fruit and involucl during germination.

*Embryo* comparatively large, but falling short of the endosperm, straight, axial, yellowish; cotyledons plano-convex, oblong, obtuse, entire, sessile, lying in the broader plane of the seed; radicle oblong, obtuse, with a slightly turbinate point, about half as long as the cotyledons, lying close to the upper end of the seed.

#### Germination and Seedling (figs. 449, 450).

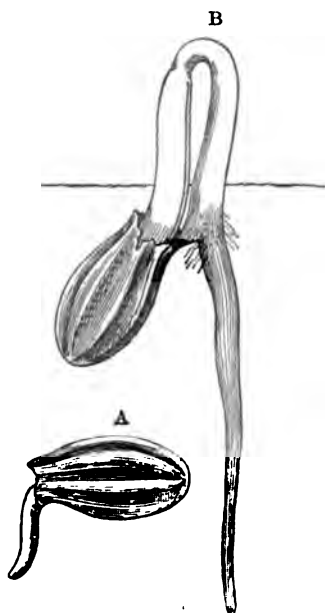
The achene closely occupies the interior of the involucl, so that in germination the radicle gets outside immediately and pushes down straight into the soil for a considerable depth, at the same time giving off numerous root-hairs. There are no perforations below the rim of the involucl, nor are they needed, on account of the shortness of the neck and the small lamina.

If the involucl is fairly well covered with soil the cotyledons, after the long radicle has established itself, are easily and readily pulled out clear of the seed and its investments. The cotyledons in this species are not very broad, because the seed itself is not very thick.

The base of the hypocotyl has a thickened projecting ledge which presses against the rim of the involucl and pins it to the earth while the arching upper part grows upwards and extricates the cotyledons (fig. 449, B).

About two days after germination the latter become free, and are linear, obtuse, emarginate, and tapering slightly to the base.

FIG. 449.—*Scabiosa australis*, × 6.  
Commencement of germination.



About four days after germination they are oblong, obtuse, much broader and more distinctly emarginate, tapering at the base into a short petiole, with a distinct midrib, and glabrous.

The cotyledons ultimately become broadly oblong, distinctly emarginate, cuneate at the base, petiolate, trinnerved at the base, or for the greater part of their length, and alternately nerved upwards (the venation is best seen on the under surface), glabrous, bright green above, paler beneath; petiole flattened above, very slightly connate at the base.



The first pair of leaves are broadly oval, slightly emarginate, suddenly narrowed at the base into short, channelled petioles, obscurely alternately incurvinerved on the upper surface, bright green and shining, but distinctly nerved underneath and paler, glabrous.

On the upper side of the cotyledon, close to the edge of the sinus, are about three large water-pores in connection with the vascular system at the apex of the midrib. The smaller cells of the tissue in that region seem to determine the slower rate of growth resulting in the emargination of the cotyledons.

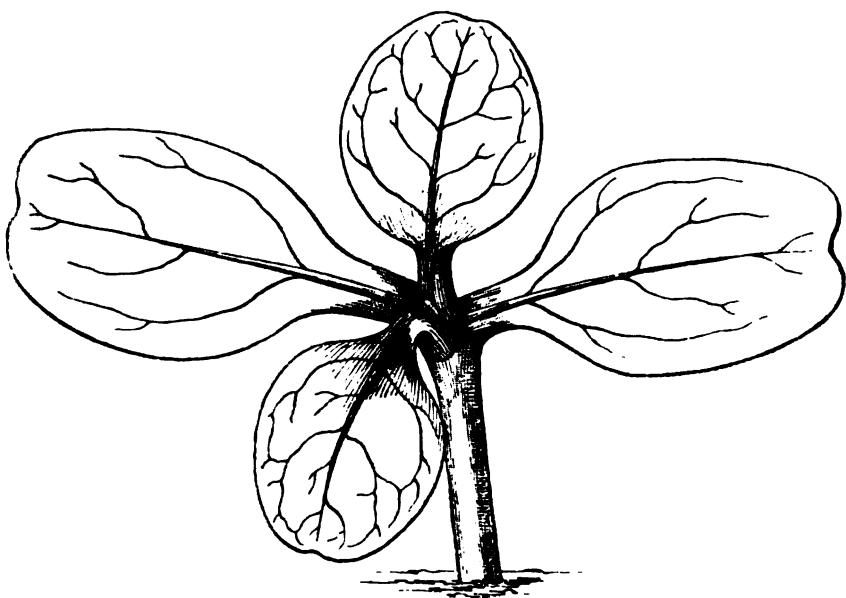


FIG. 450.—*Scabiosa australis*,  $\times 6$ . Seedling, forty-four days after germination.

*Scabiosa palæstina*, L. (fig. 451).

*Achene* closely surrounded and enclosed in an involucl, thin-walled, membranous, pale-coloured, eight-ribbed longitudinally, pubescent, produced into a long slender beak or neck, expanding into a short cup from which spread ten to twelve long feathery rays.

*Involucl* turbinate, longitudinally eight-ribbed, perforated with as many openings near the top, above which it expands into a broad, nearly or quite flat, many-ribbed, scarious lamina, with the ribs exerted as marginal teeth, more or less hairy.

*Seed* broadly ovoid, conforming in outline to that of the achene

in its lower and thickened part; testa membranous; hilum basal, close to the base of the beak of the ovary.



FIG. 451.—*Scabiosa palestina*.  
Involucel, containing fruit,  $\times 8$ .

*Endosperm* copious, fleshy, white, forming a very thin layer at the edges of the cotyledons, but much thickened at their backs.

*Embryo* large, straight, nearly equal in length to the endosperm, and nearly as wide in the plane of the cotyledons, pale yellow; cotyledons obovate, or broadly oval, obtuse or rounded at the end, entire, suddenly narrowed into the radicle; radicle short, stout, turbinate, obtuse, lying in

the conical base of the seed, and in the basal part of the beak of the ovary.

#### Germination (fig. 452).

The involucre of this species is very large, and plays an important part in the economy of the plant.

The limb is salver-shaped, membranous with numerous radiating nerves running out at the margin and forming a deeply fringed border. Immediately beneath the rim are numerous perforations between the strong ribs. The radicle in germination always emerges through the opening at the apex of the involucre, easily rupturing the thin and membranous pericarp.

If the involucre with the fruit is placed mouth downward in the earth (an unnatural position), and but lightly buried or lying on the surface of the soil, the whole may be carried up with the cotyledons. If, on the other hand, the involucre is lying on its side or with its mouth upwards, the radicle proceeds freely a short distance, and then turning downwards makes its exit through one of the openings, and grows to a great depth straight down into the earth. Some seedlings in the course of germination showed a radicle measuring 2-4 cm. in length, seven days from the time of sowing. This conduct of the radicle is of great importance in a country with the dry climate of Syria, where the plant is indigenous, not only in its depth of penetration, but in effectually fixing the involucre, pericarp, ovary and testa of the seed to the earth while the cotyledons emerge and rise up free.

The cotyledons afterwards become more or less spread out, oblong, petiolate and tapering into the petiole, showing indistinctly on each

side of the midrib one or two subopposite or alternate nerves, and faintly emarginate at the apex.

Ultimately they are obovate-spathulate, shallowly emarginate, petiolate, fleshy, glabrous, with a distinct midrib, and a few alternate, ascending nerves, best seen on the under surface. Hypocotyl glabrous.



FIG. 452.—*Scabiosa palestina*,  $\times 2$ .  
Germination.

**Scabiosa Gramuntia** (fig. 453).

The radicle makes its exit at the upper end of the fruit, and then generally pierces the lamina of the involucl, fixing it to the soil by the thickening at the base of the hypocotyl, which then pulls the cotyledons out (fig. 453).

These, as soon as they have made their exit from the fruit and spread out to the light, are narrowly oblong, obtuse, entire, sessile, glabrous, narrowed to the base, pale green, with

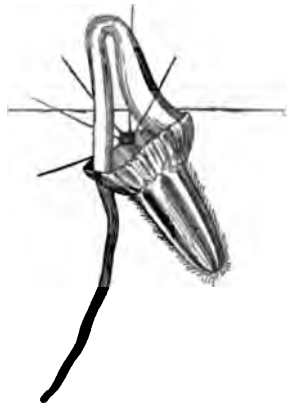


FIG. 453.—*Scabiosa Gramuntia*,  $\times 4$ .  
Germination.

an evident midrib, and about two alternate, incurved, indistinct nerves on each side.

***S. atropurpurea*, Wulf.**

**Germination and Seedling** (fig. 454, D).

The sides of the involucl are moderately thick, but the middle

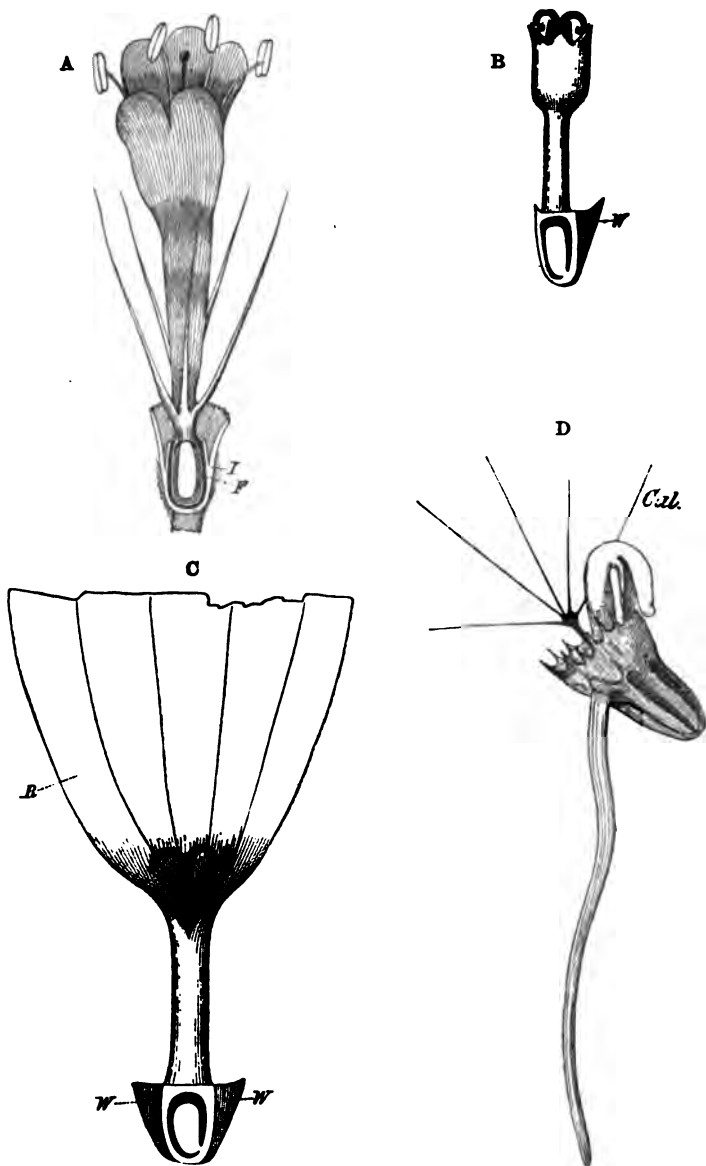


FIG. 454.—*Scabiosa atropurpurea*. A, vertical section through involucrel and ovary,  $\times 5$ : I, involucrel; F, wall of ovary. B, *Ohrysanthemum coronarium*, vertical section through ovary of hermaphrodite floret,  $\times 5$ : W, wing. C, vertical section through ovary of female floret,  $\times 5$ : W W, wings; R, ray floret with part of ligulate corolla cut away. D, *Scabiosa atropurpurea*, germination,  $\times 8$ : Cal, the five segments or bristles of the calyx.

layer consists of woody or prosenchymatous tissue, and the base is thicker. Above the lamina of the involucl the woody and compact tissue thins out and its place is taken by parenchyma, and in the young state very watery-looking tissue. The pericarp is thin and contains but a moderate amount of vascular tissue, and is therefore easily burst through when decaying by the germinating embryo.

The radicle emerges at the apex of the fruit, and immediately turns towards the earth, where it comes in contact with the involucl and pushes through one of the thin membranous parts between the ridges. The hypocotyl has an annular thickening at its base by which the fruit is held down when the radicle enters the ground. The hypocotyl then elongates and pulls the cotyledons out of the fruit as shown in the accompanying sketch (fig. 454, D).

When the cotyledons have spread out to the light about two days after germination, they are oblong or oval, obtuse, entire, narrowed slightly to the base, sessile, glabrous, and light green; the hypocotyl is glabrous and colourless.

Ultimately the cotyledons are oval-oblong, obtuse, shortly petiolate, 1.3 cm. long including the petiole, 7 mm. wide.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, or the upper sessile, sparingly hairy; petioles channelled above, dilated, amplexicaul and connate at the base.

First pair obovate-spathulate, crenate-serrate.

Second pair similar, but much larger.

Third pair spathulate-elliptic, obtuse, attenuate at the base, serrate.

Fourth pair elliptic-oblong, coarsely incise-serrate.

Fifth pair oblong, pinnatipartite; segments oblanceolate, acute, entire or slightly toothed.

Sixth and seventh pairs oblong, pinnatipartite; segments long, linear, acute, entire or sparingly toothed.

*Scabiosa caucasica*, *M. Bieb.* (fig. 455).

The radicle emerges at the apex of the fruit and, immediately turning towards the earth, penetrates the thin membranous part of the involucl between the thickened ridges directly beneath the thickened rim. The radicle is long and strong, fixing the seedling firmly in the soil. The base of the hypocotyl is thickened as in the other species described, but this thickening seems generally if not always to push through the involucl and is consequently functionless.

The cotyledons are gradually pulled out of the fruit by the energy of the growing hypocotyl.

**Seedling.**

*Hypocotyl* erect, terete, glabrous, herbaceous, 5.5 mm. long, green, reddish at the base, 1.5 mm. thick, sometimes subterranean.

*Cotyledons* broadly oblong, entire, sessile, glabrous, 1.2 cm. long, 9 mm. wide, amplexicaul.

*Leaves* simple, radical and cauline, opposite, exstipulate, shortly petiolate, penninerved.

First pair oblanceolate, entire, glabrous, 4.1 cm. long, and about 6 mm. wide, with a strong midrib sunk on the upper side and prominent beneath.

Radical leaves of adult plant spatulate, acuminate, decurrent for some distance on the edges of the broad, channelled, pale-coloured petiole, penninerved with ascending and slightly anastomosing nerves, glabrous, ciliate, deep green above with the midrib sunk above and prominent beneath.

Cauline leaves variable, like the radical ones, but the greater number pinnatipartite, with linear, acuminate, segments, sessile; terminal lobe or segment large, lanceolate, acuminate, entire or slightly out at the base. Otherwise like the radical leaves.



***Scabiosa rutæfolia*,  
Vahl (fig. 456).**

*Hypocotyl* subterranean.

*Cotyledons* oblong, obtuse or emarginate, one-nerved, tapering into a short petiole, glabrous, 1.3 cm. long including the petiole, 6 mm. wide.

FIG. 455.—*Scabiosa caucasica*,  $\times 3$ . A, commencement of germination. B, day after commencement: B, thickened base of hypocotyl; C, cotyledons.

*Stem* herbaceous, erect, terete, hairy in lines decurrent from the basal edge of the petioles, purplish; 1st internode undeveloped; 2nd 2 mm. long; 3rd 6 mm.; 4th 2 cm.; 5th 1·7 cm.

*Leaves* opposite or verticillate (in threes), simple, cauline, exstipulate, petiolate, ciliate and sparsely hairy. When the leaves are verticillate those of the first whorl are spatulate, obtuse, slightly serrate near the apex, gradually narrowed into the slender channelled petioles.



FIG. 456.—*Scabiosa rutafolia*.  
Nat. size.

In the second whorl they are similar but larger.

Those of the third whorl are oblanceolate, obtuse, serrate along the upper third, narrowed gradually into slender petioles.

In the fourth whorl they are pinnatipartite with 1-2 segments on each side, and a terminal one; segments oblanceolate, obtuse, smallest towards the base and the terminal one largest.

Those of the fifth whorl have two linear segments at each side,

and a terminal, larger and oblanceolate one, decurrent with a narrow margin nearly or quite to the base.

In seedlings with opposite leaves the first pair (as shown in fig. 456) are spatulate, obtuse, and slightly serrate near the apex.

The second pair are oblanceolate, serrate near the apex.

The third pair are oblong-oblanceolate, incise and rather obtusely serrate, gradually narrowed into long slender petioles, channelled on the upper side.

The fourth pair are similar, but have an oblong, obtuse, entire lateral segment near the base.

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## COMPOSITÆ.

Benth. et Hook. *Gen. Pl.* ii. 163.

*Fruit and Seed.*—The ovary is inferior and syncarpous, consisting of two carpels, as appears from the two divisions of the style, but it is one-celled and contains a solitary, basal, erect, anatropous ovule with an inferior micropyle. The fruit is an achene, dry, rarely fleshy, crowned with an exceedingly varied persistent pappus or calyx in different genera, or sometimes the pappus is entirely absent. The solitary seed is erect and straight or curved in conformity with the size and shape of the cavity of the achene. The testa is membranous, rarely thickened and generally free from, but sometimes adherent to, the walls of the ovary. No endosperm is present; and the embryo occupies the whole interior of the seed to which it conforms. The cotyledons are semiterete or flattened or rarely slightly convolute, and although frequently more or less curved in conformity with the achene, they are seldom unequal in length, as occurs for instance in *Coreopsis Atkinsoniana*. The radicle seems always to be short and inferior.

Exceptional cases occur in *Balbisia* where the cotyledons are conduplicate, in some species of *Robinsonia*; and in some species of *Gymnolomia*, *Sclerocarpus*, *Baltimora*, and possibly in a few other genera where they are concave or channelled



on the inner face, or in cases where they are unequal, the apex of the longer one is inflexed.

The seeds observed may be most readily classified according to the shape of the embryo, and that part of the achene which contains it, regardless of the numerous modifications of the pappus or calyx which have no direct bearing upon this. One of the simplest types of the embryo is that seen in the species of *Senecio*. The fruit of *S. erucæfolius* is short oblong-cylindrical and suddenly narrowed or contracted at the base. It is surmounted by a pappus of long scaberulous hairs, and the embryo conforms to the internal cavity. The achene of *Senecio cruentus* is covered with small papillæ in numerous apparently double lines. The fruit and embryo of *Odontospermum spinosum* are more decidedly obovoid, and the pappus consists of a few, short, stout teeth. The achenes of *Lonas inodora* and *Moscharia pinnatifida* (fig. 485) are also short and obovoid, but they are more or less compressed with the embryo conforming. The cotyledons of the latter are emarginate, owing apparently to the more rapid growth of the tissues on each side of the apex. The pappus consists of unequal hairs placed obliquely on the achene which is enclosed by a large and curious bract.

Many species belonging to different natural groups agree in possessing narrow spathulate, linear or cylindrical fruits with correspondingly narrow and elongated embryos. The achene of *Ursinia speciosa* (fig. 478) is cylindrical, slightly curved and narrowed towards the base. The pappus consists of five oval or ovate, entire, hyaline scales. The fruit of *Tragopogon minor* is cylindrical, slightly curved, more or less ridged and prolonged at the apex into a long slender beak, bearing the pappus. That of *Rhagadiolus stellatus* is also elongated, terete or compressed. The fruits of *Dahlia variabilis*, *Lasthenia glabrata* and *Layia platyglossa* are spathulate, more or less compressed and narrowed to the base. Those of *Bidens humilis* are linear, obtusely tetragonal, and much elongated with a corresponding embryo. The pappus consists of two horn-like processes. The fruits of *Tagetes erecta*, *T. patula* and others, are thin, and much compressed like those of *Dahlia*.

The species of *Helianthus* and perhaps some other of their allies may constitute another group characterised by their large seeds and oblong-obovate, obtusely tetragonal fruits which in transverse section appear of rhomboid outline. The cotyledons of *Helianthus annuus* are broadly oblong, plano-convex, and entire, and suddenly narrowed into a short radicle. Those of *H. cucumerifolius* differ in their much smaller size, and in being slightly emarginate, sometimes owing to a depression at the apex of the achene.

The species of *Coreopsis* are notable for their short, flattened, winged or variously but unequally thickened fruits. The winged condition is well shown in *Coreopsis auriculata* (fig. 462), the fruits of which are obovate or, with the wings, often suborbicular. The latter sometimes form a continuous border to the lateral margins of the achene, but more often are interrupted or broken in various places. The embryo is broadly oval with a very short radicle. The fruit of *C. Atkinsoniana* (fig. 460) is similar in outline, but the wings are absent, and instead of being biconvex it is concavo-convex owing to the inrolling of the thickened margin. The embryo is somewhat curved longitudinally, and has short roundly obovate cotyledons. *C. filifolia* (fig. 463) differs markedly from either, in the seed being subcylindrical, and slightly compressed, with the fruit greatly thickened on the dorsal surface by means of cortical outgrowths or blunt protuberances. The embryo is curved with linear cotyledons.

The relative size, shape, and number of fruits on a receptacle have all a direct bearing upon one another.

For instance, if the receptacle is narrow and flat it will bear but a few fruits, or if they happen to be numerous then a large number of them fail to reach maturity. This is well shown in *C. filifolia*, which has from sixty-five to seventy-six fruits on a narrow flat receptacle. Few of them reach maturity, and those are narrow, as may be seen by reference to fig. 463.

On the other hand, *C. auriculata* bears from seventy to one hundred and ten fruits on a receptacle which is broader than in *C. filifolia* and elevated into a distinct torus. The fruits

are very broad and winged, and, notwithstanding the width and elevated character of the receptacle, comparatively few reach maturity. On the other hand, the distribution of the fruits which do mature is aided by wing-like developments of their edges. These facts are borne out by other species examined, of which a description is given below. Another very noticeable fact is that a larger proportion of the fruits of annual species seem to reach maturity than in the case of perennials. The fruits of *Bidens humilis* and *B. leucantha* are very narrow, and a large percentage of them reach maturity. Both are annual species, and the barbed character of the pappus of some, including *B. leucantha*, is well adapted to ensure the distribution of the fruits.

The polymorphic forms of the fruits of *Calendula* even on the same receptacle are very remarkable. In *C. officinalis* at least three very distinct types may be noted. Two or three rows round the margin of the receptacle consist of greatly elongated, curiously constructed, curved achenes, muricate on the back, often beaked at the apex and produced into a hook-like process near the base on the inner face. The middle set of fruits is furnished with broad wings involute at the margin, but neither beaked at the apex nor produced into a foot at the base. Those about the centre of the receptacle are greatly incurved, often forming a complete ring, and have narrow wings involute at the margin. Transverse sections of each series give a good idea of the structure of the three different forms. The embryo is cylindrical in all three cases, curved, gradually tapered into the radicle, and otherwise similar except that the middle series is not so strongly curved.

It would seem as if we have here three devices for promoting dispersion—this being effected in the outer seeds by the presence of a hook, the intermediate ones by means of a wing, and those in the centre by resemblance to an insect.

During germination all three kinds behave in a similar manner, except that in the broadly winged fruits of the middle series the radicle (fig. 477) runs along the groove formed by the strongly involute wings till it reaches the apex of the fruit when it turns downwards and enters the soil, firmly fixing the

fruit to the ground while the elongating hypocotyl extricates the cotyledons. In all three cases the radicle emerges at the base of the fruit which splits longitudinally by three valves, thus facilitating the exit of the embryo. The splitting of the fruit is brought about by the force of the rapidly swelling cotyledons. When the latter have got quite clear, they are spathulate-oblong, obtuse, entire and tapered to the base.

The fruits of *Calendula pluvialis* are dimorphic. Those at the periphery of the receptacle are broadly obovate or suborbicular, flattened, and smooth with broad flat wings. The embryo is straight in conformity with the fruit, and has linear-oblong or spathulate cotyledons. The other fruits are obovoid, not flattened, and muricate all over the surface. In *C. hybrida* the fruits are also dimorphic. The outer ones of the receptacle are obovate, much flattened with broad flat wings. Those of the centre of the receptacle are obovoid, slightly curved or straight, trigonous and toothed on all the three angles. The embryo is straight or nearly so in both cases with linear-oblong rather fleshy cotyledons. The fruits of *C. gracilis* are also somewhat dimorphic judging from the specimens observed. One kind is curved so as to form a complete annulus, and it is muricate in transverse wavy ridges. In the other case the annulus is not complete and the muricate ridges on the back are nearly obsolete.

There are three or four different forms of fruit in *C. algarbiensis*. Those on the periphery of the receptacle are oblong, straight or slightly curved, not winged but prolonged at the apex into a slender beak. The next series consists of fruits with narrow, strongly involute wings, muricate along the back with three rows of teeth, and coiled so as to form a complete annulus. In a third set of fruits the annulus is less complete, the wings are absent, and the back is merely rugose in transverse obtuse ridges. In the fourth or central series the fruits are very small, apparently imperfect, and not completely annular.

*Seedlings*.—The prevailing type of the cotyledons in the seedling stage is spathulate, a shape due to that of the seed, which in turn conforms strictly to the interior of the fruit,

Thus in some species the cotyledons are linear, sometimes of considerable length; in others the fruits widen until we have obovate cotyledons; while in a few cases they are ovate and pointed. We may comprise in the first division those which are relatively short in proportion to their width. This is fairly well represented by *Chrysanthemum segetum*, which has spatulate-oblong, obtuse, short, sessile cotyledons, slightly connate at the base forming a little cup round the plumule or axis. This latter character is widely prevalent amongst the Compositæ. The primary leaves are oblong, and more or less deeply pinnatifid and toothed. *C. carinatum* (fig. 472) differs chiefly in the first two leaves being narrower and pinnatifid with oblong, entire segments. The seedling of *Anacyclus radiatus* is much taller with all its parts more elongated. The two primary leaves are divided to the midrib with bifid and a few entire segments. *Achillea Millefolium* (fig. 470) has shorter cotyledons and the first two leaves are opposite, tapering into a petiole, with one or two teeth on each side above the middle. The cotyledons of *Matricaria Parthenium* are also small. The first leaf is small, spatulate, and entire or nearly so, while the second is cuneate and trifid. The other leaves show great increase in size and an interesting evolution as far as division is concerned. The division of the foliage of *Matricaria globifera* is even more complicated, with the ultimate segments linear. The first two leaves are small, spatulate-cuneate and five-toothed. The first two of *Matricaria nigellæfolia* (fig. 478) are opposite, narrowly lanceolate and entire, the third is cuneate, trifid, alternate, and the fourth pinnatifid. The cotyledons are considerably elongated. *Lonas inodora* (fig. 469) has a superficial resemblance to the last, but the cotyledons are short and oval, while the first three pairs of leaves at least are opposite, the first pair being lanceolate and entire, followed by two cuneate and trifid pairs.

Another group of plants belonging to the same extensive tribe as the last, namely the Anthemideæ, has the cotyledons short or narrow and small. Those of *Anthemis* sp. (fig. 471) are linear-oblong and 5 or 6 mm. long. The first pair of leaves are pinnatisect with linear segments and very different

from the first pair of *A. mixta*, which are linear, entire, long, slender, and narrower than the cotyledons. The third leaf of the latter is pinnatisect and alternate. The cotyledons of *Artemisia Mutellina* are linear-spathulate, and the first four or five leaves are linear and entire. Strikingly different is *A. annua*, having oblong cotyledons about 2.5 mm. long, and the first two leaves short, cuneate and tri-fid or -dentate. The ultimate leaves are tripinnatisect with toothed segments. The first two of *Pentzia virgata* are linear, entire, and slightly broader upwards, while the cotyledons are spathulate-oblong and 3-4 mm. long. The first pair of leaves of *Cenia subheterocarpa* are linear, slender, entire, followed by three other pairs which are more or less divided. *Cotula coronopifolia* is somewhat similar in its early stages, but only the first pair of leaves are linear and entire, and the cotyledons are narrowly spathulate.

A group of plants belonging to several other tribes may be mentioned here on account of the similarity of the cotyledons to those of *Chrysanthemum* and its allies. The shortly oblong cotyledons of *Brachycome iberidifolia* (fig. 457) very nearly resemble those of *Achillea Millefolium*. The first two leaves are linear and entire, while the third has one or two teeth on each side near the apex. The first three pairs of leaves of *Charieis heterophylla* are oblong or spathulate-oblong, sometimes pinnatifid and hairy, while the cotyledons are oblong or often almost obovate. The same, or nearly the same, characters apply to *Madia corymbosa*, except that the seedling is stronger, or the hypocotyl longer. *Lactuca lævigata* (fig. 488) presents no affinity with the above, but the cotyledons are spathulate, tapering into a short petiole. The first leaf is oval with a long petiole, the second lanceolate with a much longer petiole, while the third leaf is lyrate-pinnatifid with the lateral segments slender.

A second type of short cotyledons is represented by *Bellis perennis* (fig. 458). The cotyledons are rotund or orbicular, petiolate, emarginate, or less frequently entire. As in the first type the petioles are more or less connate at the base. The two first leaves are rotund and nearly or quite entire. Around this type a number of species belonging to widely

different tribes may be grouped. The cotyledons of *Rudbeckia serotina* are shortly petiolate, while the first three leaves are ovate or lanceolate, and trinerved, with long petioles. The cotyledons of *Guizotia abyssinica* are pubescent as are the two lanceolate primary leaves. The first two of *Senecio erucæ-folius* (fig. 475) are oval, smooth and entire, while the ultimate leaves vary from pinnatifid and pinnatipartite forms to those that are twice divided. The cotyledons are oval and entire immediately after germination, but they soon become emarginate and ultimately orbicular. The emargination is due to the more rapid growth of the sides as compared with the apex. Those of *Leuceria senecioides* are rotund, emarginate, cuneate at the base and ciliate when young. The two primary leaves are obovate or cuneate and repandly dentate or shallowly lobed, penninerved and finely pubescent. The cotyledons of *Odontospermum spinosum* are oblong-orbicular, entire, glabrous, and much larger than the first two leaves which are oblanceolate and coarsely hairy. A striking departure from the above is met with in *Senecio cruentus* which has oblong-ovate or roundly ovate, subemarginate cotyledons, also auricled at the base, or slightly cordate, with slender petioles. The hypocotyl is very short. This differs widely from all other species of *Senecio* observed, and is evidently a rare type amongst the *Compositæ*. The first three leaves are cordate, repandly dentate, and also constitute an exception in the Order. The cotyledons of *Moscharia rosea* (fig. 486) are oblate, emarginate and truncate at the base greatly resembling those of *Cuphea silenoides*, a species of *Loasa*, or a *Labiata*. The two first leaves are sinuately pinnatifid. The form of the cotyledons is already well marked in the seed, but they widen considerably and change their form after germination.

The second division—including the elongated or large cotyledons—is the largest, and apparently contains the more typical forms occurring in the Order. The species may be grouped into those having linear, narrowly spathulate, broadly spathulate, obovate, ovate and lanceolate cotyledons. There is, however, every intermediate gradation between these types, so that the one merges insensibly into the

other. In many cases, however, a large number of the species belonging to the different types constitute groups which are more or less closely allied and belong to the same genus or tribe.

As a fairly representative seedling with linear cotyledons, I may refer to that of *Ursinia speciosa* with linear, entire, fleshy, glabrous and sessile cotyledons. The first two leaves are opposite and pinnatisect with linear segments; succeeding ones are more or less divided; and the ultimate ones are again like the first. They are auricled at the base from the fifth leaf onward and superficially appear to be stipulate. The cotyledons of *U. anthemoides* are broader and longer, while the first two leaves are like those of *U. speciosa*. The allied *Coreopsis gigantea* (fig. 464) has much longer cotyledons than either of the last two, and they are slender and somewhat undulated. The primary pair of leaves are similar to those of *Ursinia speciosa*, but the linear segments are longer. The ultimate leaves are bipinnatisect with long, linear, slender segments. The cotyledons of *Bidens humilis* (fig. 465) are linear and very small. The leaves are opposite, dimorphic and present a very interesting case of evolution. The first pair are pinnatisect with linear segments, and succeeding ones are two or three times pinnately cut or multisect. In a batch of plants about half grown, many of them will produce leaves on the upper part of the stem of a different character from those described. They are ternately pinnatisect, with triangular or ovate segments, generally cuneate at the base, the terminal one largest and simply or doubly incise-serrate.

A number of species belonging to different genera may be grouped together here on account of the resemblance of the seedlings both as regards the cotyledons and the primary leaves. They are mostly annual and the cotyledons are narrowly linear, frequently semiterete, and the first pair of leaves are opposite and similar to the cotyledons, but longer and rather broader especially above the middle. *Coreopsis filifolia* and *C. Douglasii* are instances, at least as regards the first pair of leaves. *Relhania sessiliflora* has the first seven pairs of leaves linear, entire, and gradually longer



and broader than the cotyledons. The first three or four pairs of the leaves of *Burrielia gracilis* are precisely similar to, but larger than, the cotyledons. The same may be said of *Bæria chrysostoma*. The leaves of *Microseris Bigelovii* are alternate, and the first six at least are linear and slightly widened above the middle. The primary leaves of *Tragopogon crocifolium* are also linear and slender and the ultimate ones are never very wide. The cotyledons vary from 7.5-8.5 cm. in length. The two species last mentioned belong to the tribe Cichoriaceæ and therefore have no affinity with those previously mentioned with linear cotyledons and leaves. *Tussilago Farfara* (fig. 474) has linear cotyledons, but they are small, and possibly do not exceed 5 or 6 mm. in length. The first leaf is spathulate; the second ovate; the third similar or triangular; and the fourth and fifth are cordate, recalling the primary ones of *Senecio cruentus*, to which it is more closely allied than to any other in the group of species with linear cotyledons. The narrowness of the cotyledons as far as I have observed bears a direct relation to that of the fruit and seed in which they were developed. *Lasthenia glabrata* has linear cotyledons, and the two first pairs of leaves are similar but larger. The cotyledons of *L. obtusifolia Bridgesii* show a tendency to be spathulate-linear, and while yet in the seed are spathulate-obovate. The species may be regarded as an intermediate type tending towards those having strictly spathulate cotyledons.

A fairly representative type of the spathulate cotyledons is furnished by *Cryptostemma calendulaceum*. The first two leaves are spathulate and slightly dentate. Succeeding ones are broader, and from the fourth onward they are lyrate-pinnatifid. Evolution of the leaves is also exhibited by *Dahlia variabilis*, the first four pairs of which are ovate, and the fifth pair more or less pinnatisect. *Tagetes patula* (fig. 467) and *T. glandulifera* have also very typical cotyledons, with the primary leaves opposite, pinnatisect, and their segments extremely unequal in size. A peculiarity of *T. patula* is that the under side of the cotyledon has a submarginal line of glands similar to those on the leaves. The first pair of leaves

of *Bidens ferulæfolia* are pinnatifid, and the cotyledons linear-spathulate. Those of *Heterospermum diversifolium* are spathulate while the leaves are opposite, or verticillate in threes, and the first pair linear-spathulate, as is the first one of *Haplopappus*, all the others being alternate and the cotyledons linear-spathulate. Those of *Urospermum* are broader and more typical; and the first leaf is oval, entire, and ciliated. The cotyledons of *Rhagadiolus stellatus* (fig. 487) conform to the type, but the species belongs to the tribe Cichoriaceæ, and has runcinate leaves decurrent upon the petiole; the first one has a broadly-elliptic and short lamina suddenly cuneate at the base and decurrent upon the petiole. *Gerbera lanuginosa* (fig. 484) forms a rather distinct type with spathulate-oblong cotyledons and slender petioles. The first leaf is rhomboid and angled while the second is cordate, and the ultimate ones lyrate-pinnatifid, or slightly runcinate. The cotyledons of *Coreopsis laciniata*, *C. tinctoria*, *C. coronata* and others have shortly and rather broadly spathulate cotyledons, tapering into long petioles. The leaves of the first pair are spathulate, rather broader than the cotyledons, and those of the second often similar but broader, and *C. coronata* may have several pairs which are oval or bluntly elliptic and entire. A striking departure from the type, and a rare form amongst the Compositæ is presented by *C. Atkinsoniana* (fig. 461). The cotyledons are unequal, a character due to the fruit being considerably curved and concave. Immediately after germination they are broadly oval, tapered to the base and sessile, but they gradually become petiolate. Other rather exceptional cases are met with in *Layia heterotricha* (fig. 466) and *L. elegans*, the cotyledons of which are spathulate, emarginate, rather retuse and cuneate at the base.

With the exception of *Senecio erucæfolius* and *S. cruentus*, and the two rare types above given, all the other species coming under my notice agree pretty closely with one another in the shape of their cotyledons, which may be described as oblong-spathulate, and as a rule suddenly tapered into a rather long petiole. *S. vulgaris* represents this type pretty fairly. The first leaf is spathulate, obsoletely serrate; the

next four are oblong-spathulate, irregularly dentate ; and the rest mostly lyrate-pinnatifid. *S. squalidus* has rather broader leaves, but the first five do not otherwise greatly differ from those of *S. vulgaris*. Two species are notable for the shortness of their hypocotyl, namely *S. viscosus* and *S. polycephalus*. The first four leaves vary between ovate and oblong-oval. The cotyledons of the second species are rather the broader. Those of *S. elegans* are narrowly spathulate and more like the general type of the extensive group with spathulate cotyledons reminding us of *Tagetes*. The first four leaves are rotund and more or less angled or obsoletely dentate, while succeeding ones are lyrate-pinnatifid with a rounded sinus. The first twelve leaves of *S. neelgherianus* are spathulate and merely differ in size and depth of toothings. Possibly the ultimate leaves are also spathulate. An uncommon form is met with in *S. speciosus* which has spathulate cotyledons, connate at the base. The first leaf is broadly elliptic, while the four succeeding ones are more decidedly elliptic and obsoletely dentate. The ultimate leaves are strap-shaped, pinnatifid and dentate. The cotyledons of *S. pulcher* are inclined to be elliptic. The first leaf is spathulate; the second and third rotund; the fourth oblong, and the ultimate ones oblong or elliptic, fleshy and unequally dentate. An unusual type occurs in *S. tetranthus* where the cotyledons are broadly oval or elliptic with long slender petioles, and the first leaf is broadly ovate, slightly dentate and hairy.

I pass on now to the broadly spathulate type. It is difficult to define the exact limits of this group, considering that in rich soil or under otherwise favourable conditions seedlings of many species sometimes attain exceptional vigour, and the cotyledons develop greatly in length or breadth, or both. The species of *Centaurea* and *Carduus*, or most of the tribes represented by these genera, have large seeds and embryos, and their cotyledons therefore often attain a large size. The *Centaureas* are represented by *C. Clementei* (fig. 482), which has broadly spathulate leafy cotyledons. The first leaf is also spathulate, entire, and trinerved, but is acute at either end. Two or more of the primary leaves of *C. ragusina* are spathulate and entire, followed by some that are ovate and dentate.

The ultimate ones are lyrate-pinnatifid. The cotyledons of *Gaillardia pinnatifida* (fig. 468) are oblong-spathulate and very variable in size according to vigour. The first three leaves are similar but larger and petiolate, while the ultimate ones are entire or sublyrate-pinnatifid.

The cotyledons of *Carduus giganteus* are obovate-oblong or spathulate, petiolate, connate at the base, slightly penninerved, and shallowly emarginate. The first two leaves are lanceolate-elliptic, spiny, hairy and rather smaller than the cotyledons. *Silybum Marianum* (fig. 481) has very similar cotyledons. The leaves are variously blotched and reticulated with silvery white. The two first ones are oval succeeded by two or three oblong, and all are doubly spiny-toothed at the margin. *Cnicus syriacus* has leaves somewhat similarly blotched to those of the last named, and the first six are elliptic or oblong-elliptic and spiny-toothed. The cotyledons are broad and slightly emarginate. *Cnicus diacanthus* (fig. 480) has also broadly spathulate cotyledons, and the first three leaves are oblanceolate and slightly spiny-toothed. The ultimate ones are strongly spiny, and all have the midribs and principal nerves of a silvery white. The cotyledons of *Tyrinnus leucographus* are oblong and subfleshy. The leaves are irregularly blotched with silvery white as in the case of *Silybum Marianum*; the first two are oval and minutely spiny-toothed, succeeded by three others which are oblong or oblong-obovate, lobed and spiny. The cotyledons of *Zollikoferia* are spathulate-obovate, trinerved and slightly emarginate, and the first two leaves are oval and finely repandentate.

There is no exact line of demarcation between broadly spathulate cotyledons and those which may more rightly be termed obovate, as the one type gradually merges into the other. The obovate type is represented by *Venidium calendulaceum*. The cotyledons have also a well-marked emargination and the first two leaves are lanceolate, trinerved, hairy and entire. *Gundelia Tournefortii* may also be placed here. Its cotyledons have a curious longitudinal furrow, which may or may not be median, and appears to be due to folding while yet in the seed. The seedling of *Berkheya purpurea*

(fig. 479) strongly resembles that of a *Carduus* or *Cnicus*, but the cotyledons are shorter and less tapered at the base. The first two leaves are elliptical and spiny-serrate, while the ultimate ones are ligulate or oblanceolate, undulately lobed and spiny. *Sonchus squarrosus* and *S. arvensis* belonging to the tribe Cichoriaceæ have obovate emarginate cotyledons. The first leaf of *S. squarrosus* is roundly ovate and dentate. *Helianthus cucumerifolius* (fig. 459), also belonging to a very different affinity from *Carduus*, or *Venidium*, has obovate, entire or slightly emarginate, shortly petiolate cotyledons. The first pair of leaves are oblong and entire; the second pair lanceolate; and from thence they pass through ovate to cordate or triangular forms all more or less distinctly dentate-serrate.

The ovate type of cotyledon is well represented by *Mutisia ilicifolia* (fig. 483). Here the cotyledons are ovate, acute, fleshy, both turned upon one side and recurved. The first three leaves are ovate or cordate, and repandly spiny-toothed. The cotyledons of *M. copiapina* are oblong-ovate, acute, of great size, spreading, with numerous, faint, incurved nerves. The first three leaves are oblong, sessile, and repandly spiny-toothed. In *Ainsliæa fragrans* the cotyledons are much smaller, ovate, obtuse and trinerved beneath. The first leaf is roundly cordate and pubescent. *Gamolepis annua* has broadly oblong-ovate, emarginate cotyledons, and the first two leaves at least are deeply pinnatifid with linear or narrowly lanceolate segments. *G. Tagetes* differs considerably from the last named in having oval cotyledons with a cuneate base. The first leaf is deeply trifid and all succeeding ones are pinnatisect with linear segments. Both species are annuals.

The only species having truly lanceolate cotyledons coming under my notice is *Gonospermum fruticosum*. The cotyledons are linear-lanceolate, trinerved, sessile, subacute, and 6·5 to 7·5 cm. long. The first leaf is narrowly ovate, and serrate. The three following are pinnatisect with three segments each, of which the lateral ones are very small, and the terminal ones like the first leaf, except that they are more cuneate at the base.

**Haplopappus pectinatus, Auct.**

*Primary root* very long, gradually tapering, slightly branched.

*Hypocotyl* tapering indistinguishably into the root, 2.5–3 cm. long.

*Cotyledons* linear-spathulate, obtuse, entire, slightly connate at the base, glabrous, 1.4–1.5 cm. long, 2–2.5 mm. wide.

*Stem* herbaceous, erect, terete, thinly glandular; 1st internode 2.5 mm. long; 2nd shorter.

*Leaves* simple, cauline, alternate, exstipulate, thinly glandular, tapering into the petiole which is slightly channelled above, and semiamplexicaul at the base; principal veins traversing the leaf longitudinally.

No. 1. Narrowly spathulate, entire, obtuse, mucronate.

Nos. 2 and 3. Narrowly spathulate, tapering into a slender petiole, with one or two teeth on each side near the apex.

No. 4. Spathulate, deeply incise-dentate with distant teeth.

Nos. 5–9. Deeply pinnatifid with linear-oblong, horizontally spreading segments.

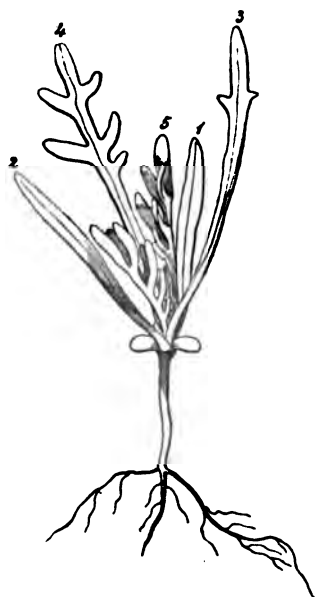


FIG. 457.—*Brachycome iberidifolia*.  
Nat. size.

**Brachycome iberidifolia, Benth.**

(fig. 457).

*Primary root* tapering downwards, with lateral fibres, annual.

*Hypocotyl* erect, terete, very short, tapering indistinguishably into the root.

*Cotyledons* short, oblong, obtuse, entire, fleshy, convex on both surfaces or nearly flat above, tapering to the base, then connate and forming a cup around the plumule, with an indistinctly discernible midrib, glabrous, light green or stained with red beneath, 4–4.5 mm. long, 1.75–2 mm. wide.

*Stem* herbaceous, annual, erect; primary internodes short or not developed.

*Leaves* simple, radical and cauline, alternate, exstipulate, petiolate, or narrowed to the base and not truly petiolate, alternately but indistinctly penninerved, fleshy or subsucculent, glabrous, light green above, paler beneath, petiole or petiole-like base, channelled

above, obtusely subcarinate beneath, dilated at the very base and subamplexicaul.

Nos. 1 and 2. Linear, obtuse, entire.

No. 3. Linear, obtuse, with one to two obtuse teeth or segments near the apex, gradually tapering with a long petiole-like base.

No. 4. Pinnatifid with two to three alternate, oblong, obtuse segments on each side.

No 5. Pinnatisect with linear-oblong, obtuse, entire segments.

No. 6. Pinnatisect with narrow, linear, obtuse, entire segments.

**Bellis perennis, L.** (fig. 458).

*Primary root* tapering downwards, flexuose with numerous lateral, flexuose, simple or branching fibrous rootlets.

*Hypocotyl* erect, very short, mostly subterranean and passing insensibly into the root.

*Cotyledons* rotund, entire, or more frequently minutely and shallowly emarginate, petiolate, light green above, paler beneath, with an indiscernible venation, glabrous; lamina horizontal, 8.5-9.75 mm. long, 8.5-4 mm. wide; petiole broad, flattened above, convex on the back, dilated and connate at the base, pale green or almost colourless, ascending, 1.5-2 mm. long.

*Stem* creeping and rhizomatous, seldom ascending, but undeveloped in the young state, ultimately branching; primary internodes undeveloped.

*Leaves* simple, radical, alternate, exstipulate, petiolate, alternately incurvinerved and obscurely reticulate, hairy on both surfaces, bright or deep green above, paler beneath; petioles obtusely keeled or rounded on the back, channelled above, dilated at the base.

Nos. 1 and 2. Rotund, nearly or quite entire.

No. 3. Rotund, obsoletely glandular-dentate, or denticulate.

**Charieis heterophylla, Cass.**

*Primary root* tapering downwards, with numerous lateral fibres.

*Hypocotyl* obconical, short, 6-7 mm. long, light green or colourless.

*Cotyledons* obovate-oblong, obtuse, entire, fleshy, sessile, glabrous, green, one-nerved, slightly unequal.

*Stem* erect, terete, herbaceous, hirsute; 1st internode 7-8 mm. long; 2nd about the same; 3rd shorter.



FIG. 458.  
*Bellis perennis.*  
Nat. size.

*First leaves* simple, entire, cauline, opposite, decussate; later ones alternate, oblong or spatulate, tapering at the base to a broadish petiole, hirsute, green, very indistinctly pinnatinerved; some of the later leaves appear sessile and slightly toothed.

***Belhania sessiliflora*, Thunb.**

*Hypocotyl* erect, terete, glabrous, 2–9 mm. above the soil.

*Cotyledons* linear, acute, sessile, subfiliform or terete, glabrous, green or stained with purplish-brown, 1·2–1·5 cm. long.

*Stem* herbaceous, annual, erect, terete, glandular-hairy; 1st internode 4–7 mm. long; 2nd similar.

*Leaves* simple, entire, cauline, opposite, decussate, exstipulate, sessile and slightly connate at the base, glandular-hairy, with the midrib slightly furrowed above and prominent beneath.

First to seventh pairs linear, acute, gradually longer, and broader than the cotyledons.

***Odontospermum spinosum*, Auct.**

*Achene* hairy; *pappus* simple.

*Seed* obovoid, about 2 mm. long; *testa* smooth, thin, dark brown; *hilum* inconspicuous.

*Embryo* straight, filling the entire cavity of the seed, greyish or colourless; *cotyledons* thick, fleshy, oblong, obtuse, sessile, entire; *radicle* inferior, terete, obtuse, very much shorter and rather narrower than the cotyledons.

**Seedling.**

*Hypocotyl* erect, terete, short, about 7·5–10 mm. long, light green or colourless, glabrous.

*Cotyledons* almost orbicular, entire, obtuse, glabrous, shortly petiolate, dark green; *venation* indistinct.

*Stem* with the first internodes undeveloped, the leaves appearing immediately above the cotyledons.

*Primary leaves* simple, entire, narrow, obovate or obtusely oblanceolate, tapering at the base but scarcely petiolate, exstipulate, ciliate and covered all over with bristly hairs; *venation* represented by a prominent midrib.

***Rudbeckia serotina*, Sweet.**

*Hypocotyl* short, hardly appearing above the surface of the soil.

*Cotyledons* subrotund, obtuse, minutely emarginate, fleshy, glabrous, green, with no apparent *venation*, very shortly petiolate.

*Stem* with primary internodes undeveloped.



*First leaves* simple, radical, entire or slightly serrate, alternate, petiolate, exstipulate, broadly lanceolate, subacute, hirsute, green, trinerved; petiole very long, covered with stiff bristles, deeply channelled on the upper side.

***Helianthus annuus, L.***

*Achene* obovoid, much compressed, but thickest near the apex, tipped with the persistent base of the flower, glabrous, brown, striped or mottled with grey; outer coat thin, membranous; inner thickened or subwoody at the lateral edges.

*Seed* obovate, much flattened but obtusely tetragonal, conforming in outline to the achene, but shrunk when dry; testa thin, membranous, white, closely applied to the seed.

*Endosperm* absent.

*Embryo* large, straight, conforming in outline to the seed; cotyledons obovate, obtuse, entire, plano-convex, closely applied to each other face to face, colourless; radicle short, turbinate, obtuse.

***Helianthus cucumerifolius, A. Gray* (fig. 459).**

*Achene* differs from that of *H. annuus* in being much smaller, oblong-obovate, and obtusely tetragonal with the lateral angles smaller and more obtuse, while the apex is more truncate, and sometimes depressed, causing an emargination of the cotyledons.

*Primary root* slender, colourless, with a few fibrous lateral rootlets.

*Hypocotyl* herbaceous, terete, glabrous, about 8 cm. long, 1 mm. thick, brownish-green.

*Cotyledons* subsessile and semiamplexicaul, 1.2–1.5 cm. long, over 5 mm. wide, obovate-spathulate, rounded at the apex, entire or slightly emarginate, obscurely nerved, glabrous, thin, light green.

*Stem* with the first internode 5 mm. long, terete, succulent, green, covered with silky hairs.

*Leaves* cauline, opposite, exstipulate, simple, connate and clasping the bases of their petioles.

*First pair* entire, oblong, obtuse, obscurely trinerved, coarsely pubescent on both sides, tapering into the channelled petiole, 2.5 cm. long, 5–7 mm. wide; petiole 8–5 mm. long.

*Second pair* lanceolate-ovate, obtuse or subacute, trinerved, serrulate with gland-tipped serratures, coarsely pubescent above, almost villous beneath, with short petioles.



FIG. 459.  
*Helianthus*  
*cucumerifolius.*  
Half nat. size.

Ultimate leaves cordate-acuminate or more often triangular, acute or subacuminate, more or less cordate at the base, trinerved in the lower half and alternately penninerved upwards, coarsely and irregularly toothed, scabrous on both surfaces.

**Guizotia abyssinica, Cass.**

*Hypocotyl* erect, terete, pubescent, 8–15 mm. long, light green or colourless.

*Cotyledons* ovate-orbicular, obtuse, emarginate, petiolate, pubescent, dark green, pinnatinerved, like the leaves.

*Stem* erect, terete, herbaceous; 1st internode 2–3 mm. long.

*First leaves* simple, entire, cauline, opposite, lanceolate, obtuse, shortly petiolate, exstipulate, pubescent, light green, pinnatinerved.

**Heterospermum diversifolium, H. B. K.**

*Primary root* soon giving off very strong lateral rootlets which keep the primary one in check, annual.

*Hypocotyl* erect, terete, glabrous, 5–8 mm. long.

*Cotyledons* spatulate, obtuse, entire, sessile, tapering to the base and slightly connate, glabrous, with a distinct midrib, 1–1.3 cm. long, 2–2.75 mm. wide above the middle.

*Stem* annual, herbaceous, erect, terete, somewhat striate, with rows of hairs from the edges of the leafstalks downwards; 1st internode 8–4 mm. long; 2nd 7–11 mm.

*Leaves* simple, cauline, opposite, decussate or verticillate in threes, exstipulate, somewhat hairy on both surfaces, with strong, sharply-ascending nerves; petioles channelled above, slightly connate at the base.

First pair linear-spatulate, obtuse, entire, or sometimes sub-cuneate, rather deeply trifid.

Second pair ovate, pinnatifid, with about five segments.

Third to sixth pairs ovate-elliptic or subrhomboidal, cuneate at the base and shallowly serrate, not pinnatifid.

**Coreopsis Atkinsoniana, Dougl. (fig. 460).**

*Achene* oval in outline, convex both in a longitudinal and transverse direction dorsally, but involute at the margins and concave ventrally, with a small, somewhat elevated scar at either end, smooth on the back and minutely dotted or reticulated, or distinctly echinulate, black.

*Seed* obovate, curved longitudinally and compressed dorso-ventrally, conforming to the interior of the fruit; testa pale or whitish,

thin, membranous; hilum and micropyle inferior, contiguous; chalaza apical, superior.

*Endosperm* absent.

*Embryo* large, straight or slightly curved longitudinally, conforming to the interior of the seed, colourless; cotyledons rotund-

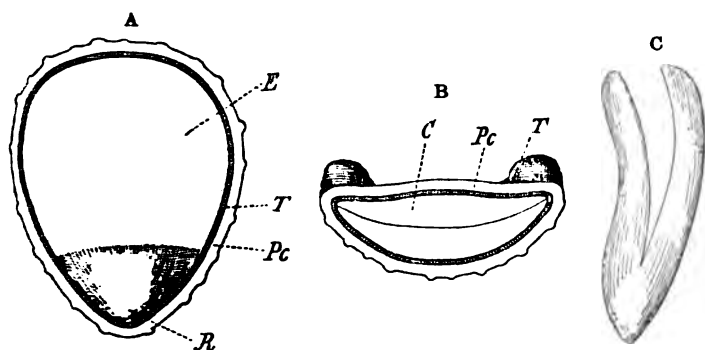


FIG. 460.—*Coreopsis Atkinsoniana*,  $\times 20$ . A, longitudinal section of achene: *E*, embryo; *T*, testa; *Pc*, pericarp; *R*, radicle. B, transverse section of achene: *C*, cotyledon; *Pc*, pericarp; *T*, testa. C, embryo, showing edges of cotyledons and their relative length to the radicle.

obovate, entire, plano-convex and closely applied face to face, lying in the broader plane of the seed with their back towards the axis of the receptacle or inflorescence, much longer than the very short, turbinate, obtuse radicle at the base of the seed.

#### Germination (fig. 461).

The fruit splits vertically along each side, that is right and left corresponding with the position of the cotyledons in the broader plane of the seed and fruit.

The radicle emerges at its base and fixes itself in the ground while the cotyledons increase in size and escape from the fruit. The cotyledons are tinged with purple.

When the fruit has been insufficiently covered, it is often carried up by the germinating embryo.

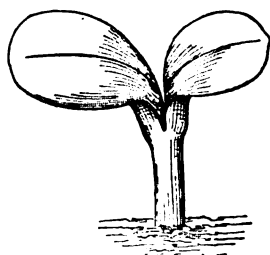


FIG. 461.  
*Coreopsis Atkinsoniana*,  $\times 6$ .

The figure shows the seedling as it appears three days after germination. The cotyledons are broadly oval, obtuse, entire, narrowed at the base into a short

petiole, glabrous, pale green, more or less stained with purple, somewhat unequal in size owing to their position in the curved seed and fruit. In twelve out of fifteen seedlings the cotyledons were markedly unequal; in the other three only slightly.

*Coreopsis auriculata*, L. (fig. 462).

*Achene* obovate, winged, wings nearly entire or oftener more or less cut into shreds or short filaments, convex on the dorsal aspect and somewhat curved, subconcave when dry and curved longitudinally on the ventral aspect, with a callosity at its base and a large one at the apex, or two more or less combined, smooth on the dorsal aspect, minutely tuberculated on the ventral, black.

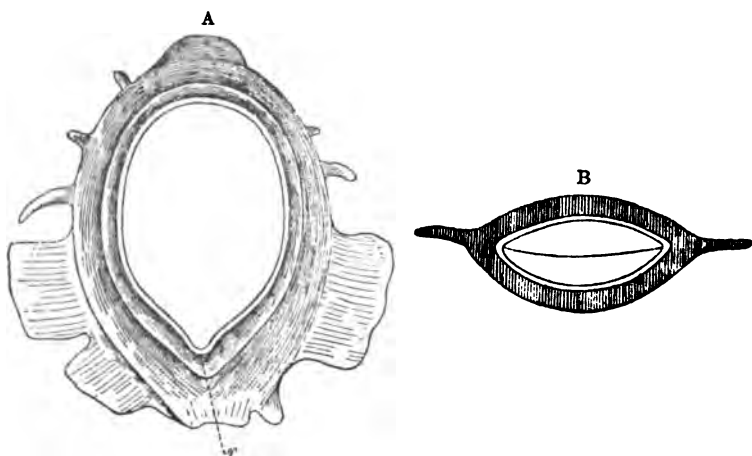


FIG. 462.—*Coreopsis auriculata*. A, longitudinal section of achene,  $\times 14$ : r, radicle. B, transverse section of achene,  $\times 14$ .

*Seed* conforming in outline to the cavity of the achene, rounded at the end, suddenly tapered to an obtuse point, much compressed dorso-ventrally, surrounded by a dark line on the middle of both dorsal and ventral aspect, slightly curved longitudinally like the achene; hilum basal; chalaza apical; testa thin, pale, membranous.

*Endosperm* absent.

*Embryo* large, slightly curved in accordance with the achene and seed, colourless; cotyledons obovate or broadly oval, rounded at the apex, entire, suddenly narrowed to the radicle; radicle very short, obtuse.

***Coreopsis filifolia*, Hook. (fig. 463).**

*Achene* linear or subcylindrical, narrow, biconvex, smooth on the ventral aspect, obtusely muricate on the dorsal, curved outwards in the middle or away from the central axis, shortly two-horned at the apex, with a slightly oblique, somewhat thickened basal scar.

*Seed* cylindrical, conforming to the shape of the achene, curved; testa thin, membranous, white; raphe and chalaza inconspicuous; micropyle and hilum basal.

*Endosperm* absent.

*Embryo* slightly curved, filling the seed, pale yellowish-white; cotyledons linear, obtuse, entire, plano-convex; radicle turbinate, obtuse, about one-fourth the length of cotyledons.

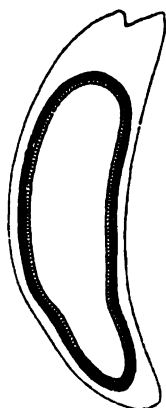


FIG. 463.—*Coreopsis filifolia*. Longitudinal section of achene,  $\times 14$ .

***Coreopsis gigantea*, Benth. (fig. 464).**

*Primary root* slender, tapering downwards.

*Hypocotyl* erect or ascending from a thickened base, terete, glabrous, shining, red at the base and pale green above, and more slender, 2.5–4.5 cm. long.

*Cotyledons* linear, obtuse, subundulate, subsucculent, flattened and slightly channelled along the midrib, horizontal, 2.5–3 cm. long.

*Leaves* simple, pinnatisect, cauline, opposite, exstipulate, petiolate, subsucculent, glabrous; petioles subterete, channelled above.

First pair pinnatisect with two pairs of lateral, and one terminal, linear, obtuse segment. The ultimate leaves are triangular in outline, two to three times pinnatisect; segments all slender, filiform, slightly channelled above.

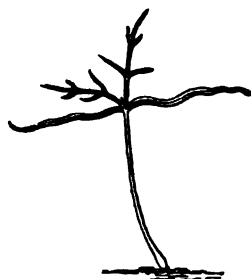


FIG. 464.  
*Coreopsis gigantea*.  
Half nat. size.

***Coreopsis laciniata*, Auct.**

*Primary root* short, suddenly tapering, branched, annual.

*Hypocotyl* very short, tapering indistinguishably into the root, 5–8 mm. long.

*Cotyledons* shortly spatulate, tapered into a long petiole, entire with a black gland at the apex, an indistinct midrib and a marginal nerve best seen on the under surface, glabrous; lamina 4-5 mm. long, 2.5-3 mm. wide; petiole flattened above, connate at the base round the stem, 5-5.5 mm. long.

*Stem* herbaceous, erect, terete, glabrous; 1st internode 4-5 mm. long; 2nd 1.6-1.8 cm.

*Leaves* nearly or quite glabrous, with indistinctly reticulate venation; petiole connate at the base, channelled above, with a few hairs on the margin at the base.

First pair spatulate, obtuse, entire, with long petioles.

Second pair spatulate, or oblong-elliptic, obtuse, entire, with long petioles.

Third pair pinnatifid; with about two pairs of lateral lobes, linear, obtuse, entire; terminal lobe lanceolate, obtuse, entire, tapered to the base, much longer than the lateral ones.

#### COMPARATIVE SIZE AND NUMBER OF FRUITS IN COREOPSIS.

*Coreopsis auriculata*, L.—Receptacle considerably elevated like a torus, 3.25-5 mm. in diameter, bearing seventy to one hundred and ten fruits or achenes, of which only five to fifteen ripened in the specimens examined. Achenes 3.25-3.5 mm. long, 2.5-3.5 mm. wide, .75-1 mm. thick, slightly curved longitudinally and concave on the ventral face.

*C. filifolia*, Hook.—Receptacle flat or slightly convex, 3-4.5 mm. in diameter, bearing sixty-five to seventy-six achenes, of which four to fifteen ripened in the specimens examined. Achenes narrow, somewhat curved longitudinally, 3.75-4.25 mm. long, 1.25 mm. wide, 1 mm. thick.

*C. lanceolata*, L.—Receptacle convex, 4-5 mm. in diameter, bearing seventy to eighty-five achenes. Achenes flattened, or convex on the back, ciliated at the margins, terminating in two teeth.

*C. latifolia*, Michx.—Receptacle flat, 3-4.25 mm. in diameter, bearing eighteen to thirty achenes, of which very few (one to two or more) ripened in specimens examined. Achenes oblong, compressed, two-edged, with a ridge along each face, ending in two very short blunt teeth, slightly curved longitudinally, 7-8 mm. long, 2.25-2.75 mm. wide, 1-1.3 mm. thick.

*C. tinctoria*, Nutt.—Receptacle 3.5-5 mm. in diameter, slightly convex, bearing one hundred to two hundred achenes, of which forty to one hundred and forty-five ripened in specimens examined. Achenes longitudinally curved, rounded and

echinulate on the back, flattened and slightly convex on the face, minutely reticulate, 1·5–2 mm. long, ·75–1 mm. wide, ·25–·33 mm. thick.

*C. Atkinsoniana*, Dougl.—Receptacle elevated, 2·5–6·75 mm. in diameter, bearing eighty to one hundred and thirty-six achenes, of which fifty to ninety-four ripened in specimens examined. Achene almost semiglobose, concave on the ventral aspect, echinulate dorsally, 2–2·25 mm. long, 1·5–1·75 mm. wide, ·5–1 mm. thick.

*C. bicolor*, Rehb.—Receptacle convex, 3·5–6 mm. in diameter, bearing one hundred and eighty to two hundred and sixteen achenes, of which one hundred to one hundred and sixty ripened in the specimens examined. Achene 2–2·33 mm. long, ·75–1 mm. wide, ·25 mm. thick, oblong, slightly curved longitudinally, and generally tapering slightly to the ends, with a small white basal callosity, minutely echinulate on both surfaces.

### *Dahlia variabilis*, Desf.

*Achene* narrowly obovate or spathulate, notched at the apex with a little tooth in the sinus, giving the whole a tridentate appearance, compressed, obtusely ancipitous, disarticulated at the base transversely, with a shallow oval areola, black.

*Seed* conforming to the interior of the fruit, but readily separable from it; testa thin, pale or colourless, longitudinally striate.

*Endosperm* absent.

*Embryo* straight, occupying and conforming to the interior of the seed, fleshy, colourless; cotyledons spathulate, obtuse, entire, tapering gradually to the short radicle, plano-convex and applied to each other, face to face; radicle inferior, obtusely pointed, close to the hilum.

### Seedling.

*Primary root* long, tapering, with lateral rootlets, ultimately supplanted by more or less fusiform tubers springing from below the cotyledons, and in close proximity to them.

*Hypocotyl* subterranean or indistinguishable from the root.

*Cotyledons* spathulate-linear.

*Stem* erect, terete, herbaceous, hairy, ultimately glabrous or thinly hairy, greenish-purple, striated with darker lines; 1st internode 14 mm. long; 2nd 4 mm.; 3rd 2·5 mm.; 4th 5 mm.

*Leaves* opposite, pinnatisect, glabrous above except on the nerves, deep green, ciliate at the margins, paler beneath and hairy; petioles channelled on the upper side, and more or less winged.

First pair ovate, obsoletely serrate, cuneate at the base.

Second pair ovate, rather coarsely dentate-serrate.

Third pair similar but more rounded at the base.

Fourth pair unequal; one leaf ovate, serrate; the other tripartite with ovate, serrate segments; the lateral ones much the smallest.

Ultimate leaves pinnatisect, with three to five or more segments; segments ovate, acuminate, coarsely serrate, opposite, the lower pair generally stalked with or without two small segments on their basal posterior side. Upper leaves tripartite; uppermost undivided and shortly stalked or sessile or reduced to bracts.

***Bidens humilis*, H. B. K.**

*Achene* linear, very narrow, obtusely tetragonal with shallow ridges and furrows between, glabrous, black; two of the angles predominate and are produced into two horns surmounting the fruit.

*Seed* linear, slightly broader than thick, conforming to the interior of the achene, only falling short of the length of the cavity; testa thin, membranous, white or nearly so; micropyle and hilum contiguous, basal, inferior; chalaza superior.

*Endosperm* absent.

*Embryo* comparatively large, filling the entire seed, straight, colourless; cotyledons linear, obtuse, entire, plano-convex, closely applied face to face, lying in the broader plane of the seed with their backs to the axis of the receptacle, narrowed somewhat towards the base; radicle terete, obtuse, slightly shorter than the cotyledons, pointing to the base of the fruit but some distance above it.

*Receptacle* somewhat concave, 3-3.5 mm. in diameter, bearing forty to sixty achenes, of which thirty-five to fifty ripened in the specimens examined. Achenes linear, slender, straight, 5-7 mm. long, exclusive of the awns or teeth, .75 mm. wide, .5 mm. thick, four-ribbed longitudinally.

**Seedling (fig. 465).**

*Primary root* long, flexuose, with numerous lateral rootlets, annual.

*Hypocotyl* erect, terete, glabrous, reddish, about 8 mm. long.

*Cotyledons* linear, obtuse, subfleshy, flattened above with a sunk midrib, convex beneath, broadest above the middle, amplexicaul and connate at the base, about 1 cm. long, 1-1.25 mm. wide.

*Stem* herbaceous, annual, erect, terete, densely covered with hyaline, coarse, jointed hairs, and densely pubescent especially when young; 1st internode 5.5 mm. long; 2nd 9 mm.; 3rd 1.1 cm.; 4th 1.8 cm.; 5th 4 cm.; 6th 2.5 cm.



*Leaves* simple, bi- to tri-pinnatisect, or by reversion pinnatisect, opposite, more or less hairy on both surfaces with a line of short incurved hairs along the sunk median nerve of every segment, deep green above, pale beneath; petioles hairy, channelled above, convex on the back, dilated and amplexicaul at the base.

First pair trifid or pinnatifid with two linear obtuse segments on each side.

Second pair with a short broadly triangular limb, pinnatisect with the basal segments largest and trifid.

Third pair triangular, bipinnatisect, with oblanceolate-linear segments.

Fourth pair triangular-ovate, bipinnatisect with the secondary segments slightly cut.

Fifth pair triangular-ovate, bipinnatisect.

Ultimate leaves triangular-ovate, bi- to tri-pinnatisect with the ultimate segments oblanceolate-linear or oblong, entire or slightly cut, acute. By reversion many of the stems and branches produce, towards the top, leaves that are merely ternately pinnatisect with triangular or ovate pinnatifid or merely incise-dentate segments, and broad slightly toothed lobes.

Nearer the top of these branches the leaves are ternately pinnatisect with ovate, acute incise-serrate segments.

*B. leucantha*, Willd.—Receptacle slightly concave in the early stages, ultimately flat or somewhat convex, 4·25–7 mm. in diameter, bearing fifty to seventy-one achenes of which thirty-seven to sixty-four ripened in the specimens examined. Achenes linear, slender, obtusely tetragonal, with a few ascending bristles towards the apex, and terminated by two to four awns, of which two are nearly always the strongest and all furnished with reflexed bristles, 6·5–13·5 mm. long, .75–1·25 mm. wide, .75–1 mm. thick.

*Bidens ferulæfolia*, DC.

*Hypocotyl* as in *B. humilis*, but 2–3·5 cm. long, and light green or colourless with occasionally a faint reddish tinge.

*Cotyledons* linear-lanceolate, acute, entire, tapering to the base, but not petiolate, fleshy, glabrous, light green, one-nerved.

*Stem* herbaceous, erect, terete, finely pubescent; 1st internode about 2–4 mm. long.

*First leaves* cauline, petiolate, pinnatifid, lobes 3–5 mm. long, the end one considerably the largest, acute, light green, pinnati-

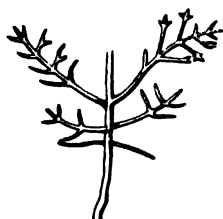


FIG. 465.—*Bidens humilis*.  
Half nat. size.

nerved with a lateral nerve running up each lobe, surface with a few hairs. The first pair as in many other Compositæ are opposite.

***Madia elegans*, Don.**

*Hypocotyl* erect, terete, glabrous, 5-6 cm. long, light green or colourless.

*Cotyledons* broadly spatulate, emarginate, obtuse, sessile, connate at the base, fleshy, glabrous, dark green, one-nerved, the nerve only apparent at the base of the lamina.

*Stem* ascending, herbaceous, pubescent; 1st internode about 2 mm. long.

*First leaves* simple, entire, cauline, opposite, decussate, linear, subacute, ciliate, thickly covered with hairs, with those on the under side much smaller, light green, distinctly one-nerved.

***Layia platyglossa*, A. Gray.**

*Achene* obovate or spatulate, ribbed and covered with numerous hairs; pappus short, coronate.

*Seed* conforming in shape to the achene, exalbuminous; testa membranous, thin; hilum inconspicuous.

*Embryo* straight, filling the interior of the seed, colourless; cotyledons spatulate, obtuse, emarginate (on account of a depression of the pericarp beneath the style), sessile; radicle terete, obtuse, not quite so long as the cotyledons.

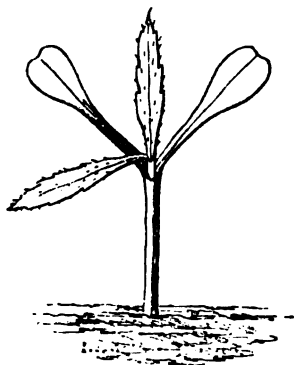


FIG. 466.—*Layia heterotricha*.  
Nat. size.

***Layia heterotricha*, Hook. et Arn.  
(fig. 466).**

*Hypocotyl* erect, terete, glabrous, 1.2-1.5 cm. long, light green or colourless.

*Cotyledons* spatulate, obtuse, emarginate, tapering to a long narrow base but hardly petiolate, fleshy, light green, indistinctly one-nerved, glabrous.

*Stem* with the primary internodes but slightly developed.

*First leaves* linear-spatulate; the first pair are opposite, acute, denticulate, tapering to the base but hardly petiolate, hairy, with a distinct midrib.

The seedling of *Layia elegans*, Torr. et Gray, closely resembles the above.

***Burrielia gracilis*, DC.**

*Primary root* slender, fibrous, annual.

*Hypocotyl* terete, glabrous, 8–12 mm. long.

*Cotyledons* linear, obtuse, entire, connate at the base and sheathing the stem, glabrous, 1–1·6 cm. long.

*Stem* herbaceous, annual, erect or procumbent, terete, glabrous or nearly so at the base, and covered with an adpressed pubescence upwards; 1st internode 1–2·7 cm. long.

*Leaves* simple, entire, cauline, opposite, sessile and connate at the base, very thinly pubescent, semiterete, channelled on the upper side.

First to third or fourth pair precisely similar to the cotyledons, but larger.

***Bæria chrysostoma*, Fisch. et Mey.**

*Primary root* annual, long, tapering gradually and giving off only a few slender rootlets.

*Hypocotyl* short, terete, glabrous, tapering indistinguishably into the root.

*Cotyledons* linear, semiterete, slightly flattened above, obtuse or subacute, connate at the base and sheathing the stem for 8 mm., very sparsely pilose, 4–4·5 cm. long, about ·5 mm. wide, recurved at the tip.

*Stem* herbaceous, erect, terete, glabrous or thinly pilose; 1st internode 1·4–1·7 cm. long; 2nd 1–1·2 cm.

*Leaves* simple, cauline, opposite, sessile and sheathing at the base, pilose and ciliate at the margin, subsequently more or less glabrescent.

First pair linear, obtuse, or subacute, semiterete, slightly flattened above and curved at the tip like the cotyledons, which they resemble in general appearance.

Second pair broader, linear, obtuse, channelled above, slightly carinate beneath, coarsely and thinly ciliate at the margin, recurved at the tips.

Third pair similar, but broader and recurved at the tips.

***Lasthenia glabrata*, Lindl.**

*Primary root* long and gradually tapering downwards, but slightly branched, annual.

*Hypocotyl* short, or tapering indistinguishably into the root.

*Cotyledons* linear, connate at the base, sheathing the stem, flattened above, 2–2·5 cm. long, 1 mm. wide.

*Stem* herbaceous, annual, erect, terete, glabrous, green and shining; 1st internode 2-2.5 cm. long; 2nd 1.5-1.8 cm.

*Leaves* as in last species, connate and sheathing at the base, bright green and glabrous, entire.

First pair linear, obtuse, entire, flattened above, slightly broader above the middle, resembling the cotyledons.

Second pair linear, obtuse, flattened above, entire.

Third pair much broader, linear, obtuse, slightly channelled above, entire.

***Lasthenia obtusifolia*, Cass., var. *Bridgesii*.**

*Achene* obovate-oblong, suddenly narrowed to the base, compressed, slightly keeled on one side, glabrous, 3-3.5 mm. long by 1.25-1.5 mm. wide about or above the middle.

*Seed* conforming to the shape of the achene.

*Embryo* conforming to the shape of the seed; cotyledons spatulate-obovate, blunt or slightly emarginate at the apex; radicle conical, nearly as long as the cotyledons. The cotyledons after germination are linear or spatulate-linear, a shape attained by elongation after germination.

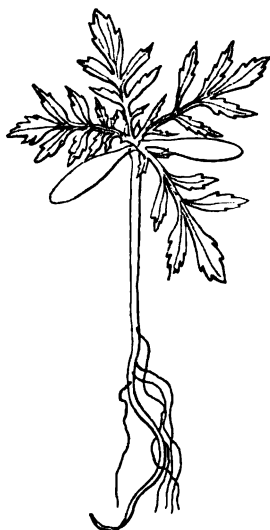


FIG. 467.—*Tagetes patula*.  
Nat. size.

***Tagetes patula*, L. (fig. 467).**

*Primary root* tapering, flexuose colourless, with many fleshy, colourless, flexuose, fibrous rootlets, annual.

*Hypocotyl* erect, terete, deep dull purple, closely striate with scabrid lines of papillæ-like hairs, 1.5-2 cm. long.

*Cotyledons* narrowly spatulate, sub-fleshy, pale green above, paler beneath, with a prominent midrib and a sub-marginal row of brownish glands; petiole slightly furrowed above, scabrous beneath, 6 mm. long; limb oblong-obtuse, glabrous, 1.3 cm. long, 4 mm. wide.

*Stem* herbaceous, annual, terete, glabrous, dull purple; early internodes very short.

*Leaves* simple, pinnatisect, cauline, opposite, sessile, glabrous, with a sub-marginal line of brownish glands on the lobes or segments.

First and second pairs much alike; basal segments very small, spatulate, acutely tri-dentate or -fid; middle segments lanceo-

late, acute, serrulate above the middle; terminal segment lanceolate-elliptic, acute, serrate from the middle upwards; lateral segments alternate; rachis and midrib of segments channelled.

*Tagetes glandulifera*, Schrank.

*Primary root* very similar to that of *T. patula*.

*Hypocotyl* minutely scabrid, pale purple, 2.1 cm. long, 1 mm. thick.

*Cotyledons* very similar to those of *T. patula*, tapering into a short petiole, connate at the base, 1.6 cm. long, 8.5 mm. wide.

*Stem* angled and furrowed; 1st internode 4 mm. long.

*Leaves* very similar to those of the last species, pinnatisect with mostly alternate segments, and with submarginal, clear, translucent glands.

First pair pinnatisect, tapering much to the base with very unequal segments; basal ones small, slender, spathulate, tridentate, with the teeth often tipped with a bristle; upper segments lanceolate, subserrate; terminal segment lanceolate-elliptic, serrate above the middle.

Second pair similar, except that the terminal segment is very much the largest and oblong, acute, serrate.

*Gaillardia pinnatifida*, Torr. (fig. 468).

*Primary root* tapering, rather stout, colourless, giving off a few lateral rootlets, annual.

*Hypocotyl* 2-3 mm. above ground, 1-1.5 mm. thick, fleshy, red, frequently surrounded by the husk of the achene.

*Cotyledons* oblong-spathulate, sessile, rather fleshy, obtuse, glabrous, variable in length according to vigour of specimen, 6-18 mm. long, 4-5.5 mm. wide.

*Leaves* simple, radical and cauline, alternate, coarsely hairy on both surfaces; petioles channelled above, convex beneath or somewhat ridged, pubescent.

No. 1. Spathulate, obtuse, or sometimes narrowly elliptic, entire.

No. 2. Oblong, obtuse, entire.

Ultimate radical leaves entire or sublyrate-pinnatifid, spathulate, obtuse, tapering to the base, alternately pinninerved, with the nerves ascending and entering the lobes when



FIG. 468.  
*Gaillardia*  
*pinnatifida*.  
Half nat. size.

present, dull subglaucous-green, more or less hairy on both surfaces; petioles channelled above, shallowly ridged on the back, dilated, sheathing and crimson at the base, subscabrously hairy.

***Anacyclus radiatus, Lois.***

*Hypocotyl* erect, terete, glabrous, 8-4 cm. long, light green tinged with red.

*Cotyledons* oblong-spathulate, obtuse, entire, tapering to the base but scarcely petiolate, connate at the base, fleshy, glabrous, light green, indistinctly pinnatinerved.

*Stem* herbaceous; primary internodes undeveloped.

*First leaves* pinnatifid, cauline, alternate, with a few hairs, tapering to the base, pinnatinerved; lobes acute, entire or bifid, light green.

***Gonospermum fruticosum, Less.***

*Hypocotyl* erect, terete, covered with very minute hairs, 8.5-8.75 cm. long, brownish.

*Cotyledons* very long, linear-lanceolate, subacute, entire, tapering to the base, glabrous, green, trinerved, sessile.

*Stem* erect, terete, herbaceous, ultimately shrubby; 1st internode 2-8 mm. long; 2nd and 8rd about the same.

*First leaf* simple, ovate-oblong or almost lanceolate, acute, coarsely serrate, covered with minute hairs, green, pinnatinerved; leaves after the first one alternate, pinnatisect; terminal segment similar to the first leaf; lateral segments small, serrate, oblong, acute; petioles short, thick, deeply channelled on the upper face.

***Lonas inodora, Gaertn.***

*Seed* narrowly obovoid, subcompressed, readily removable when fresh from the achene to the interior of which it conforms.

*Embryo* conforming to the seed which it wholly occupies; cotyledons plano-convex, obtuse, entire, closely occupying the interior of the upper and broader end of the seed, and applied face to face; radicle tapering to an obtuse point and occupying the narrow end of the seed, nearly equalling the cotyledons in length but much narrower; plumule minute and scarcely, if at all, discernible.

**Seedling (fig. 469).**

*Primary root* tapering downwards, giving off slender lateral rootlets, colourless, flexuose, annual.

*Hypocotyl* erect, terete, stout, tapering into the radicle, pale green, glabrous, 8.5-5.5 mm. long.

*Cotyledons* oval, obtuse, entire, sessile, connate at the base and forming a cup round the plumule, glabrous, pale green, succulent and without any discernible venation, 4-5.5 mm. long, 3-3.5 mm. wide at the middle.

*Stem* herbaceous, erect, terete, glabrous, annual, pale green; 1st internode 7-9 mm. long; 2nd 8-10 mm.

*Leaves*.—Lower opposite, upper alternate, sessile, with a few alternate, ascending nerves on each side of the midrib, glabrous, subsucculent, light green above, paler beneath.

First pair spatulate, subacute or cuspidate, tapering gradually to the base where they are again slightly dilated and connate and grooved on the upper side, many times longer than the cotyledons, decussating with them, entire, with a distinct midrib but no other discernible venation.

Second pair spatulate-cuneate, trifid with ovate, acute, entire teeth or lobules, or the lateral ones sometimes furnished with one or two teeth on the posterior side, with a lateral nerve proceeding straight into each tooth, tapering gradually to the base where they are again slightly dilated and furnished with a number of slender, subulate or setiform teeth, carinate beneath.

Third pair cuneate, tapering to the base, deeply trifid, with oblong, slightly toothed segments, each with a strong lateral nerve, carinate on the back, somewhat dilated and connate at the base, for some distance above which they are furnished with slender, subulate, or setiform teeth.

Seventh leaf alternate in specimen examined

*Achillea Millefolium*, L. (fig. 470).

*Hypocotyl* erect, terete, glabrous, pale green or almost colourless, 6-14 mm. long.

*Cotyledons* shortly spatulate, tapering to the base and perfoliate, with an indistinct midrib and two lateral nerves arising from the base and passing round the cotyledon immediately within the margin to

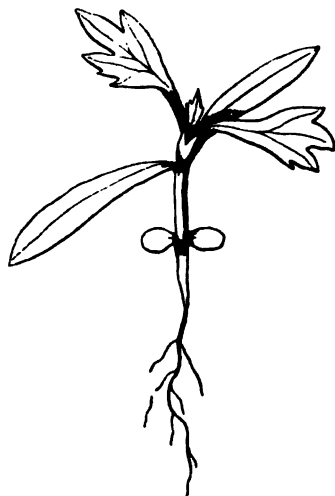


FIG. 469.—*Lonicera inodora*.  
Nat. size.

unite with the midrib near the apex, glabrous, light green above, paler beneath, 5–6 mm. long, 2.25–3 mm. wide.

*Stem* herbaceous, procumbent at the base or creeping, with erect flowering stems; primary internodes undeveloped.

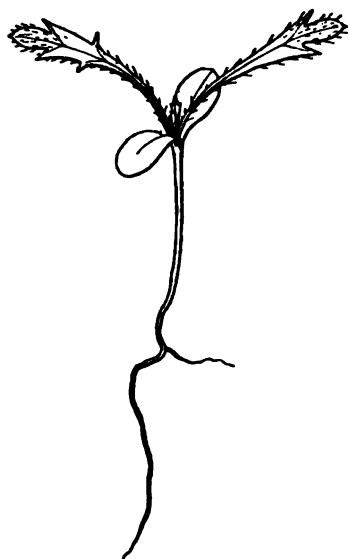


FIG. 470.—*Achillea Millefolium*,  $\times 2$ .

*Leaves* radical and cauline, alternate (first two opposite or equally developed), more or less hairy or tomentose when young, minutely scaly, deep greyish-green; petioles semiterete, deeply channelled above, dilated and clasping at the base, more or less hairy.

Nos. 1 and 2. Opposite, spatulate, acute, tapering into the petiole, always having one to two subulate, acute teeth on each side.

Ultimate leaves oblanceolate-linear in outline, two to four times pinnatisect primary and secondary segments or divisions ovate; tertiary and quaternary divisions slender, subulate or

lanceolate, acute, more or less acuminate or subaristate.

#### *Anthemis* sp. (fig. 471).

*Primary root* comparatively short, tapering rather suddenly to a fine point and giving off long, lateral, adventitious roots.

*Hypocotyl* terete, glabrous, twisted very frequently or curved, pale green, almost colourless, 1–1.5 cm. long.

*Cotyledons* shortly linear-oblong, obtuse, 5–6 mm. long, 2 mm. wide.

*Stem* herbaceous, terete or slightly angular, glabrous or minutely scabrous on the slender ridges, pale green; 1st internode 2 mm. long; 2nd undeveloped; 3rd 8.5 mm.; 4th 2 mm.

*Leaves* multisect, alternate, with amplexicaul petioles, pale green, odorous, glabrous or minutely and sparsely pubescent, chiefly on the nerves.

Nos. 1 and 2. Almost or quite opposite; lamina oblong, pinnatifid or -sect, with lanceolate, acute segments; petiole flat above, convex beneath, 1.3 cm. long.



No. 8. Pinnatisect ; lower segments small, linear, acute, entire ; upper segments lanceolate, acute, frequently cut again.

Nos. 4-6. Bipinnatisect with slender, linear-lanceolate, acute or bristle-tipped segments.

These characters are fairly constant throughout a great number of seedlings.

*Anthemis mixta*, L.

*Primary root* slender and fibrous.

*Hypocotyl* erect, terete, glabrous, reddish, 1-1.5 cm. long.

*Cotyledons* linear-spathulate, tapering to a narrow petiole-like base, obtuse, slightly connate at the base, glabrous, 1-1.6 cm. long, 2-2.5 mm. at the widest.

*Stem* herbaceous, erect, terete, glabrous ; 1st internode 2-12 mm. long, according to circumstances, and whether the seedlings are crowded or not.

*Leaves* alternate (first pair opposite), sessile, glabrous, uni- to bipinnatisect, more or less sheathing or clasping at the base.

First pair opposite, entire, long, slender, linear, acute, convex above and obtusely carinate beneath, narrower than the cotyledons and several times longer.

No. 8. Pinnatisect with a few distant, linear, acute segments by far the longest towards the apex of the leaf.

No. 4. Similar, rather more divided.

Nos. 5-7. Two to three times pinnatisect ; ultimate segments linear or linear-lanceolate, acute.

*Chrysanthemum carinatum*, Schousb. (fig. 472).

*Primary root* long, tapering, flexuose, giving off long lateral fibres.

*Hypocotyl* erect, 3-5 cm. long, 2 mm. thick, herbaceous, glabrous, shining, pale, slightly suffused with purple.

*Cotyledons* oblong, obtuse, fleshy, convex above, subrevolute at the margins, 1-1.5 cm. long.



FIG. 471.—*Anthemis* sp.  
Nat. size.

*Stem* herbaceous, annual.

*Leaves*.—Nos. 1 and 2. Linear, obtuse, distantly toothed or lobed about the middle of the lamina, amplexicaul at the base.

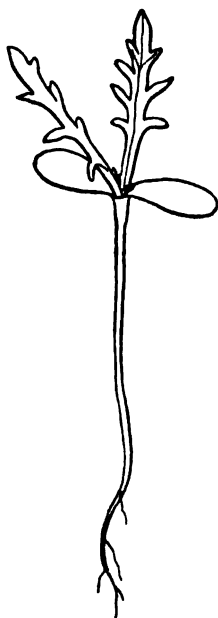


FIG. 472.  
*Chrysanthemum*  
*carinatum*. Nat. size.

No. 8. Linear-oblong, pinnatifid; lobes obtuse.

No. 4. Oblong, pinnatifid; lobes oblong, subacute or mucronate, fleshy.

No. 5. Similar, larger and toothed along the narrow petiole-like part to the amplexicaul base.

No. 6. Oblong in the upper part and pinnatisect, otherwise like No. 5.

No. 7. Pinnatisect; lobes pinnatifid or toothed. This and the younger leaves more or less glandular on the upper surface.

***Chrysanthemum segetum*, L.**

*Primary root* as in last species, annual.

*Hypocotyl* fleshy, colourless, tapering into the root, 1.65 cm. long.

*Cotyledons* very similar to those of the last species, 1.85 cm. long, 4.5 mm. thick.

*Stem* herbaceous, annual.

*Leaves* simple, radical and cauline, opposite, sessile, glabrous, more or less lobed or pinnatifid, subglaucous-green above, paler beneath.

First pair oblong, obtuse, deeply toothed with obtuse or acute, apiculate teeth, decurrent on the broad petiole-like base; margin entire; midrib prominent.



FIG 473.  
*Matricaria*  
*nigellæfolia*.  
Nat. size.

Second pair oblong, obtuse, pinnatifid, decurrent and serrate on the broad petiole-like base; lobes oblong, obtuse, dentate-serrate with obtuse or acute, apiculate serratures.

***Matricaria nigellæfolia*, DC. (fig. 473).**

*Hypocotyl* erect, terete, glabrous, 2–5 mm. long, light green.

*Cotyledons* spatulate, obtuse, entire, sessile, but tapering towards the base, glabrous, 4–6 mm. long, light green.

*Stem* erect, short, herbaceous.

*Leaves*.—First pair opposite (the others alternate), entire, cauline,

linear-lanceolate, rather obtuse, tapering at the base, glabrous, glaucous-green, midrib with numerous ascending branches.

Second and third pairs alternate, and tri-lobed or -fid.

**Matricaria Parthenium, L.**

*Primary root* long, tapering, flexuose, with numerous lateral rootlets.

*Hypocotyl* short, stout, merging into and indistinguishable from the root.

*Cotyledons* small, subobovate, sessile, 5 mm. long, 8 mm. wide.

*Stem* herbaceous, elongated when about to flower.

*Leaves* simple, radical and ultimately cauline, alternate; pubescent on both surfaces, and densely covered with sessile glands, highly odorous, more or less pinnately divided; petioles pubescent, channelled above, dilated and amplexicaul at the base.

No. 1. Spathulate, entire or one-toothed.

No. 2. Cuneate, obtuse, trifid or merely toothed.

No. 3. Shortly and broadly oblong, pinnatifid.

No. 4. Triangular, pinnatifid.

No. 5. Pinnatifid, or pinnatipartite; lobes subcuneate, toothed at the apex, or slightly cut.

No. 6. Triangular, obtuse, pinnatipartite; lobes subpinnatifid or toothed.

No. 7. Ditto; but lobes alternate, ovate and oblong, deeply pinnatifid.

Nos. 8 and 9. Triangular, almost pinnatisect; lobes ovate, pinnatifid and toothed, lower ones deeply cut on the basal, posterior side.

The *var. laciniatum* has its larger leaves pinnatisect, pinnatipartite and pinnatifid; ultimate segments subulate or lanceolate, and acute.

**Matricaria globifera, Fzl.**

*Hypocotyl* as in *M. Parthenium*, subterranean.

*Cotyledons* falling away early.

*Stem* herbaceous, erect, terete, slightly pubescent; internodes crowded or many of the lower ones undeveloped.

*Leaves* simple, ultimately pinnately multisect, radical and cauline, lower petiolate, upper sessile, glabrous, deep green with the segments convex above, minutely revolute at the margins, making a shallow channel on each side of the rather prominent midrib in the primary divisions,—the midrib is absent in the smaller divisions; petioles glabrous, flattened on the upper surface or convex, dilated and slightly channelled at the amplexicaul base, convex or deepening into a ridge beneath.

Nos. 1 and 2. Small, spathulate-cuneate, and five-toothed.

Nos. 3 and 4. Pinnatifid, short, subcuneate at the base, with entire segments.

No. 5. Short, broad, irregularly bipinnatifid.

No. 6. Bipinnatisect, the lower segments scattered.

No. 7. Shortly oblong, obtuse, bipinnatisect; lowest segment small.

No. 8. Ditto, tripinnatisect; middle segment largest and most cut.

No. 9. Oblong, obtuse, tripinnatisect with most of the primary divisions nearly equal; base of petiole with a few linear segments.

Nos. 10 and 11. Oblong, obtuse, tri- to quadri-pinnatisect, with a small detached segment about the middle of the petiole, and a few linear, mostly entire ones towards or close to the base; ultimate segments linear, acute rather thin but fleshy.

Cauline leaves sessile; larger ones bi- to tri-pinnatisect to the very base with mostly alternate segments—the middle ones largest with long, linear, slender, subfiliform acute segments.

### ***Cotula coronopifolia*, L.**

*Hypocotyl* slender, 8–10 mm. long.

*Cotyledons* oblong or linear-oblong, obtuse, or slightly spathulate, entire, connate into a cylindrical sheath at the base for about one-third of their length, and surrounding the plumule, glabrous, sessile, a midrib faintly visible, 3–4.5 mm. long in the upper free part, and 1.5–2 mm. wide.

*Stem* terete, glabrous; 1st internode .9–1.5 cm. long; 2nd shorter and often entirely covered with the leaf-sheaths.

*Leaves* simple, cauline, alternate (first pair opposite), sheathing at the base, glabrous, at least in the seedling.

Nos. 1 and 2. Opposite, linear, entire, obtuse, elongated, tapering to the base, indistinctly petiolate, but sheathing the stem with a cylinder from 3–4.5 mm. long, showing a midrib only, minutely punctate.

No. 3. Similar, and sheathing in the same way, entire or with a narrow linear, lateral segment, about or below the middle.

No. 4. Similar to the last or having a segment on each side, the segments being alternate.

### ***Cenia subheterocarpa*, Less.**

*Leaves* simple, uni- to bi-pinnatifid, cauline, lower opposite, upper alternate, sessile, hairy on both surfaces.

First pair opposite, linear, slender, entire.

Second pair opposite, pinnatisect, linear-oblong in outline.

Third pair opposite, linear-oblong, pinnatisect with the segments pinnatifid in the upper half.

Fourth pair pinnatisect, segments pinnatifid.

Nos. 9–11. Alternate, pinnatisect, segments pinnatifid ; ultimate divisions linear-lanceolate, acute, small.

Ultimate leaves oblong-linear, pinnatisect in the lower third, with slender, linear, acute segments, pinnatisect, segments again pinnatifid in the upper two-thirds, with subulate, lanceolate, acute divisions.

***Pentzia virgata, Less.***

*Hypocotyl* erect, or more or less decumbent, terete, glabrous, pale green, 5–10 mm. above the soil.

*Cotyledons* spatulate-oblong, obtuse, entire, glabrous, light green, sessile, 3·5–4 mm. long, 1·25–1·75 mm. wide.

*Stem* erect, terete, silky or almost hoary from loose or adpressed hairs, ultimately becoming shrubby ; internodes short and several of the primary ones hardly developed.

*Leaves* simple, cauline, alternate, more or less hoary with cottony, loosely adpressed hairs, light green when young, ultimately pinnatisect, with alternate segments corresponding to the venation ; petioles channelled above in the lower half, convex on the back, dilated towards the base and semiamplexicaul, hairy, pale green.

Nos. 1 and 2. Linear, subacute or obtuse, entire, slightly wider towards the top and narrowed to the base, or petiolate.

Nos. 3–6. Cuneate, trifid at apex, with acute segments, long, petiolate.

Nos. 7–9. Pinnatifid or -sect, with one or two lateral and one terminal segment ; segments linear, acute.

Nos. 10–12. Similar but with more numerous pinnae.

Nos. 13–17. Pinnatisect, pinnatifid ; ultimate segments linear-lanceolate or subulate, acute.

***Artemisia annua, L.***

*Primary root* normal, with a few lateral fibres.

*Hypocotyl* tapering into and indistinguishable from the root, colourless, fleshy.

*Cotyledons* small, shortly oblong, obtuse, 2·5 mm. long, 1·5 mm. wide.

*Stem* developed when about to flower, herbaceous, annual.

*Leaves* simple, radical and cauline, alternate, thinly pubescent, bright green above, paler beneath and rather prominently nerved,

ultimately multisect; petioles channelled above, dilated at the base, and after the leaves have attained some size auricled with irregularly cut laciniae.

Nos. 1 and 2. Small, spathulate-cuneate, tridentate at the apex.

No. 3. Cuneate, obtusely five-toothed.

No. 4. Shortly and broadly oblong, five-lobed; lobes obtuse, mostly bidentate.

No. 5. Oblong-ovate, obtuse, pinnatifid; lobes subcuneate, dentate.

No. 6. Triangular-ovate, obtuse, pinnatisect; lower lobes pinnatifid on the posterior side, coarsely dentate; upper lobes coarsely dentate.

No. 7. Triangular-ovate, pinnatisect; lobes pinnatifid and dentate.

Radical leaves numerous, ultimately triangular, bipinnatisect, ultimate segments pinnatifid to -partite; primary segments oblong—the lower two longest; secondary segments oblong, most developed on the posterior side of the primary segments; ultimate divisions oblong, cuspidate, entire, or the larger ones dentate.

#### *Artemisia Mutellina*, Vill.

*Hypocotyl* erect, terete, 3–5 mm. above ground.

*Cotyledons* linear-spathulate, obtuse, entire, glabrous, sessile, recurved, 4–5 mm. long, 1.5–1.75 mm. wide.

*Stem* herbaceous, erect, terete, nearly or quite glabrous in the young state, and then having the primary internodes undeveloped, or the first 2–3 mm. long, and the succeeding ones shorter.

*Leaves* hoary, with a silky adpressed pubescence, tapering gradually into the petioles; petiole flattened above or biconvex.

Nos. 1–4 or 5. Linear, entire, acute, the third to fifth slightly broader above the middle. In strong seedlings the fourth and fifth may be unequally bifid or subequally trifid.

Nos. 6–10. Trifid with linear, obtuse, or subacute segments, the terminal one being longest.

#### *Tussilago Farfara*, L. (fig. 474).

*Primary root* tapering, flexuose, soon supplanted by strong lateral roots from the base of the hypocotyl.

*Hypocotyl* very short, subterranean, reddish.

*Cotyledons* linear-oblong, obtuse, fleshy, shortly petiolate, dilated at the base, amplexicaul and subconnate, 5 mm. long including the petiole.

*Stem* creeping, subterranean.

*Leaves* simple, radical, alternate, fleshy, obscurely subpalmatinerved, white and cottony above when young, felted with a white cottony tomentum beneath; petioles semiterete, channelled on the upper side, at first cottony, ultimately nearly glabrous.

No. 1. Small, spatulate, obtuse, entire, mucronate.

No. 2. Ovate, with a tooth on each side or in stronger seedlings broadly ovate with two teeth on each side, mucronate.

No. 3. Similar to the last or in robust seedlings broadly ovate or triangular, obtusely five-angled, obscurely five-nerved.

No. 4. Cordate, obtusely seven-angled and sparingly and obscurely toothed between the angles.

No. 5. Similar, but more decidedly toothed between the angles.

*Senecio cruentus*, DC.

*Achene* terete, or the outer ones slightly compressed, longitudinally ribbed, and minutely transversely wrinkled or marked, glabrous, but covered between the ridges with a double row of white papillæ, dark brown, crowned with the easily removable bristly or setaceous pappus, slightly contracted at the top and forming a little cup on which the pappus is seated.

*Seed* closely conforming to the achene; testa thin, brownish; hilum and micropyle contiguous, basal; chalaza apical.

*Endosperm* absent.

*Embryo* straight, conforming to the shape of the seed, and occupying the whole of the interior, pale yellow or nearly colourless; cotyledons oblong, obtuse or rounded at the apex, entire, tapering into the radicle at the base and not auricled; radicle short, about half the length of the cotyledons, turbinate at the tip, obtuse, sometimes slightly contracted at the base of the cotyledons, close to the micropyle.

**Seedling.**

*Hypocotyl* very short.

*Cotyledons* oblong-ovate or subrotund-ovate, obtuse, subemarginate, mucronulate, fleshy, pale green above, tinted with violet beneath, glabrous; lamina 7 mm. long, 6 mm. wide; petiole flattened, glabrous, 5 mm. long.

*Stem* herbaceous, elongated when about to flower.

*Leaves* simple, radical and cauline, dull green and thinly hairy



FIG. 474.  
*Tussilago*  
*Farfara*.  
Nat. size.

above, green or more often violet beneath, and very hairy, palmately five- to seven-nerved at the base and alternately penninerved upwards; petioles semiterete, channelled above, dilated and amplexicaul at the base, densely hairy or villous.

No. 1. Cordate, obtuse, five-nerved, distantly dentate with triangular, mucronate teeth.

Nos. 2 and 3. Cordate, acute, five- to seven-nerved at the base, coarsely dentate with occasional smaller intermediate teeth, deeply auricled at the base; teeth mucronate. The ultimate leaves differ little except in size.

***Senecio erucæfolius*, Huds.**

*Achene* oblong-cylindrical, narrowed at the very base, constricted immediately beneath the base of the pappus, pubescent with lines of short ascending hairs; pappus copious, with thinly puberulous hairs.

*Seed* oblong, obtuse, narrowed slightly to the base, smooth, pale



FIG. 475.—*Senecio erucæfolius*. Two stages of seedling.

brown; hilum small, basal; raphe forming a deeper brown line along one side to the apex of the seed.

*Endosperm* absent.

*Embryo* colourless; cotyledons as in *S. cruentus*; radicle stout, obtuse, close to the base of the seed, slightly narrower than the cotyledons, but about equal in length.

**Seedling (fig. 475).**

*Hypocotyl* glabrous, 5–8 mm. long.

*Cotyledons* immediately after germination small, oval, obtuse or rounded at both ends, entire. After they have become three or four times as large, they are still oval but emarginate. Finally they become rotund, deeply emarginate, and 5–7 mm. long and wide.

The apex has three or four large open pores, which are visible under the microscope at an early stage and continue more or less distinct till the cotyledon becomes old and thick.

The cotyledon is trinerved immediately after germination. The lateral nerves and midrib are distinct in both lamina and petiole, and are continued down to the vascular bundles of the hypocotyl;



in the lamina they curve round nearly parallel within the margin, but are more or less irregular or undulated, and unite with the midrib close to the apical sinus. The midrib is also undulated or zigzag, and gives off from its angles alternate, ascending, lateral branches that unite with the lateral nerves and form a series of large reticulations.

Stomata on the under surface tolerably numerous and large; few on the upper surface, but similar to those on the under.

*Stem* herbaceous and elongated when about to flower.

*Leaves* simple, radical and cauline, petiolate or sessile towards the upper part of the stem, glabrous in the seedling, pubescent and cottony above in the adult plant, densely pubescent beneath; petioles somewhat channelled above, dilated and clasping at the base, gradually becoming shorter on the stem till the leaves are sessile.

Nos. 1 and 2. Oval, obtuse, entire, with a few alternate, ascending nerves, glabrous, bright green.

The leaves on the lower part of the stem are oblong, obtuse, pinnatifid, or coarsely dentate. The median ones are sessile, oblong, obtuse, narrowed to the base, pinnatisect: segments oblong, obtuse, more or less coarsely dentate or incise-dentate principally on the posterior side. The upper ones are shorter, sessile, much less narrowed at the base, pinnatisect with linear or oblong segments, again subpinnatifid or coarsely cut, especially on the posterior side.

*Senecio pulcher*, *Hook. et Arn.*

*Primary root* stout, colourless, tapering downwards, with lateral, adventitious roots which soon become stronger than itself.

*Hypocotyl* undeveloped.

*Cotyledons* broadly ovate-oblong, obtuse, minutely emarginate, fleshy, petiolate; venation obscure, comprising a midrib with irregular lateral branches which branch again, anastomose and unite with a slender submarginal nerve, glabrous, deep green, suffused with violet beneath; lamina 1-1.8 cm. long, 7-10 mm. wide; petiole semiterete, flattened above or shallowly grooved, dilated and connate at the base, 1.1-1.9 cm. long.

*Stem* herbaceous, and developed when about to flower; primary internodes undeveloped.

*Leaves* simple, radical and cauline; venation irregular; nerves alternate and incurving, obscurely reticulate, deep opaque green above, paler, but often suffused with violet beneath, glabrous; petiole semiterete, grooved above, dilated and clasping at the base, glabrous.

No. 1. Broadly oval or rotund-oval, obtuse, obsoletely dentate.

No. 2. Similar, but more decidedly serrate-dentate.

Ultimate leaves oblong or oblong-elliptic, unequally dentate or frequently lobulate, fleshy, alternately penninerved, glabrous or slightly woolly at the margin, with long petioles.

***Senecio tetranthus*, DC.**

*Hypocotyl* erect, becoming stouter upwards, glabrous, almost colourless or reddish, 5–7 mm. long.

*Cotyledons* oval, obtuse, entire, generally tipped with a small mucro, glabrous, with a barely discernible midrib seen only by transmitted light; lamina 5–6 mm. long, 3.25–4.25 mm. wide; petiole flat above or slightly grooved, convex on the back, 4–6 mm. long.

*Leaves* simple, radical and cauline, alternately and ascendingly penninerved, hairy all over, light green; petiole semiterete, channelled above, coarsely hairy all over with many-jointed, whitish hairs, dilated and clasping at the base.

No. 1. Broadly ovate, cuspidately subacute, with a few glandular-mucronate teeth on each side, and alternate, bent or wavy nerves not running directly into the teeth.

***Senecio vulgaris*, L.**

*Primary root* normal with numerous lateral rootlets.

*Hypocotyl* erect, terete, succulent, deep purple and shining, about 8 mm. long.

*Cotyledons* oblong-spathulate, obtuse, entire, tipped with a glandular mucro, trinerved, with the lateral nerves parallel with, and close to the margin, incurved and uniting with the midrib close to the apex; midrib giving off lateral, alternate short branches ascending irregularly, and forming a series of reticulations with the lateral nerves. The stomata are about equal in number on both surfaces, and the epidermal cells very wavy in outline. At the very tip of the cotyledon and at its apical edge are some large open pores in the glandular mucro. There are no openings on the upper or under surface corresponding to those close to the apex in *Galium Aparine* and *Lithospermum officinale*.

*Stem* herbaceous, annual, fleshy, erect, terete at the base, angled and furrowed upwards, sparsely hairy or woolly when young, ultimately almost or quite glabrous; 1st internode 4 mm. long; 2nd 2 mm.; 3rd 10 mm.; 4th undeveloped; 5th 8 mm.; 6th 5 mm.

*Leaves* cauline, lower petiolate, upper sessile, woolly or hairy at the base on both sides when young like the buds, ultimately glabrous or nearly so, deep green above, paler or subglaucous

beneath; lower petioles as well as the midribs of the sessile leaves grooved on the upper side, dilated at the base and amplexicaul.

No. 1. Spathulate, obsoletely serrate.

No. 2. Similar, but oblong-spathulate.

Nos. 3 and 4. Oblong-spathulate, irregularly doubly dentate.

No. 5. Spathulate, oblong, pinnatifid and dentate, sessile, subauricled at the base.

No. 6. Oblong, broadest at the apex, auricled at the base, sessile, more deeply pinnatifid and dentate than No. 5.

No. 7. Sublyrate, deeply pinnatifid, and irregularly incised-dentate, narrowed to the base, but sessile, auricled and decurrent on the stem.

Nos. 8-10. Deeply lyrate-pinnatifid, with linear-oblong, deeply dentate or cut segments, almost bipinnatifid, sessile, auricled and subdecurrent; margins revolute.

### *Senecio squalidus, L.*

*Primary root* tapering downwards with numerous adventitious fibrous rootlets, colourless.

*Hypocotyl* 2 cm. long, .75-1 mm. thick, becoming thickened upwards, deep dull purple.

*Cotyledons* spathulate, entire, petiolate, 1.3 cm. long; limb 3 mm. wide, glabrous, green, suffused with purple beneath.

*Leaves* cauline, petiolate, thinly pubescent on both sides, deep green above and more or less suffused with purple beneath.

No. 1. Oval, sometimes spathulate, obtuse, and cuneate at the base, obsoletely serrate; petiole somewhat dilated at the base and subamplexicaul, more or less pubescent, especially at the edges, channelled above.

No. 2. Oval, obtuse, obtusely and distantly serrate.

No. 3. Oblong, obtuse, lobed; lobes short, subserrate.

No. 4. Oblong, obtuse, more deeply lobed than the last; lobes subserrate, penninerved with alternate nerves.

No. 5. Oblong, pinnatifid, obtuse; lobes more decidedly serrate.

The stem in the young state is covered by the semisheathing petioles.

### *Senecio viscosus, L.*

*Hypocotyl* terete, about 4 mm. long, glabrous, deep purplish-red.

*Cotyledons* spathulate, obtuse, entire, glabrous; petiole slightly channelled above, 8-10 mm. long.

*Leaves* radical in the seedling; petiole subamplexicaul, channelled

above, hairy with glandular jointed hairs ; limb hairy on both sides with glandular jointed hairs.

No. 1. Oval, obtuse, obscurely penninerved, obsoletely dentate-serrate ; each serrature tipped with a gland or mucro.

No. 2. More distinctly dentate-serrate, oval.

No. 8. With broadly triangular, shallow and gland-tipped serratures, broadly oblong, obtuse.

***Senecio elegans*, L. (fig. 476).**

*Primary root* tapering, with numerous lateral rootlets, annual.

*Hypocotyl* erect, terete, greenish, succulent, 1.25 cm. long.

*Cotyledons* spatulate-oblong, obtuse, subfleshy, 9 mm. to 1.2 cm. long, 2-8 mm. wide, glabrous.

*Stem* herbaceous, annual.

*Leaves* cauline, sparsely hairy at least when young ; lamina subdecurent on the petiole ; petiole channelled above, convex beneath, hairy at the margin, dilated and sheathing at the base.

No. 1. Rotund, obsoletely dentate-serrate.

No. 2. Subobovate, obtusely dentate.

No. 8. Larger and foreshadowing division at the base.

No. 4. Broadly oblong, obovate, obtusely and shallowly lobate.

No. 5. Irregularly pinnatifid, with a small lateral obovate lobe, and a large unequally triangular, obtuse, shallowly

lobulate terminal segment ; lobes very obtuse, obsoletely mucronate-dentate along the ends, revolute at the margin.

No. 6. Similar with two small alternate, lateral segments, revolute at the margin.

No. 7. Lyrate-pinnatifid, revolute at the margin, with four alternate segments ; terminal segment much smaller than in the preceding leaves ; lobes angled or dentate along the apex.

No. 8. Lyrate-pinnatifid, oblanceolate in outline, revolute at the margin ; segments gradually smaller from the terminal, to the very small, basal ones, angled and mucronately dentate along the ends.

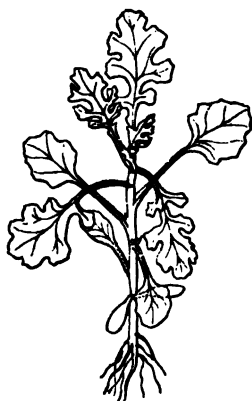


FIG. 476.—*Senecio elegans*.  
Half nat. size.

***Senecio neelgherianus*, DC.**

*Cotyledons* spatulate, obtuse, tapering to the base, glabrous, pale green, 1.1 cm. long, 4.5 mm. wide.

*Stem* subshrubby, erect, terete, slightly flexuose near the base, dull purple and densely covered with spreading jointed white hairs; 1st internode 7 mm. long; 2nd 7.5 mm.; 3rd 7 mm.; 4th 7.5 mm.; 5th 9.5 mm.; 6th 13.5 mm.; 7th 10.5 mm.; 8th 8 mm.; 9th 5 mm.

*Leaves* cauline, sessile, densely covered on both surfaces with spreading or patent, jointed, white hairs, ascending, patent, or older ones recurved, revolute at the margin from the fourth onward.

No. 1. Spathulate, entire, or obsoletely denticulate, 1.75 cm. long, 9 mm. wide above the middle, tapering to a narrow base.

No. 2. Spathulate, tapering to a narrow base, obsoletely and mucronately dentate.

No. 3. Spathulate, subserrate above the middle, tapering to a rather broad base.

No. 4. Broadly spathulate or subobovate, more decidedly serrate above the middle.

No. 5. Broadly spathulate, serrate above the middle, tapering to a broad base.

No. 6. Spathulate, with a broad base, serrate nearly throughout, apex subacute.

No. 7. Spathulate, acute, serrated to the base and subauricled; serratures largest above the middle of the leaf.

Nos. 8-12. Spathulate, acute, serrate throughout, auricled at the base and amplexicaul.

### *Senecio speciosus, Willd.*

*Primary root* slender, tapering, much branched, with long, slender, very numerous rootlets, at length overpowered by strong adventitious roots arising immediately below the leaves.

*Cotyledons* spathulate, obtuse, glabrous, rather succulent, pale green, 1 cm. long, tapering gradually into the connate petiole; petioles ascending, 7 mm. long.

*Leaves* radical, coarsely hairy on both sides and villous on the midrib beneath; pale green above and paler beneath.

No. 1. Rotund, entire, obscurely trinerved, and suddenly tapering into a broad channelled petiole; petiole subvillous, dilated and sheathing at the base.

No. 2. Broadly elliptic and rounded at the apex, distantly and obsoletely dentate at the sides, otherwise like the first.

No. 3. Obovate, obtuse, distantly serrate-dentate, obscurely penninerved.

Nos. 4 and 5. More decidedly serrate; serratures obtuse, submucronate.

Ultimate leaves linear-oblong, pinnatifid; lobes shortly oblong, toothed in an irregular or jagged manner; apex and long sub-channelled base irregularly toothed, not lobed.

*Senecio polycephalus*, *Ledeb.*

*Hypocotyl* subterranean or none.

*Cotyledons* as in *S. speciosus* but with a distinct petiole, about 1.3 cm. long including the petiole; lamina 5 mm. wide.

*Leaves* radical in young specimen, covered on both surfaces of the petiole and lamina with coarse, jointed, subglandular hairs; petiole subamplexicaul at the base.

No. 1. Ovate-oblong, obtuse, obsoletely dentate-serrate; petiole channelled above, convex below, about 1 cm. long.

No. 2. Oblong, obtuse, cuneate at the base, distantly dentate-serrate, with broadly triangular acute or mucronate serratures, suffused with purple on the under surface.

No. 3. Oblong, apex mucronate, otherwise similar to No. 2.

*Gamolepis Tagetes*, *DC.*

*Primary root* short, tapering, flexuose, throwing out strong branches at an early stage, which soon supersede it.

*Hypocotyl* suberect, terete, glabrous, deep purple, 1.8 cm. long, 1.25–1.5 mm. thick.

*Cotyledons* oval, obtuse, shortly petiolate, glabrous, deep purple; lamina 7 mm. long, 5.5 mm. wide; petiole 2.5 mm. long.

*Stem* herbaceous, annual, erect, glabrous, with angles decurrent from the base of the petioles; 1st internode 2 mm. long; 2nd 1 mm.; 3rd 3 mm.; 4th 3 mm.; 5th 6.5 mm.; 6th 1.6 cm.; 7th 2.2 cm.

*Leaves* simple, pinnatisect (after the first one), cauline, glabrous; petioles fleshy, channelled above, dilated at the base and amplexicaul.

No. 1. Tripartite, subcuneate, with flat, linear segments.

No. 2. Pinnatisect; segments in three nearly opposite pairs with a terminal one, flat, linear, subacute.

No. 3. Segments seven, fleshy.

No. 4. Segments nine, alternate, fleshy, frequently with a tooth on the posterior side.

Nos. 5 and 6. Segments linear, slightly dilated upwards, fleshy, slightly channelled on the upper side, frequently folded up face to face.

*Gamolepis annua*, *Less.*

*Hypocotyl* erect, terete, slightly hoary, 1.5–2 mm. long, reddish-green, minutely pubescent.

*Cotyledons* ovate-oblong, obtuse, very slightly emarginate, fleshy, somewhat incurved, light green above, tinged with red below, glabrous, one-nerved, with short petioles.

*Stem* short, erect, herbaceous; primary internodes very slightly developed.

*First leaves* simple, deeply pinnatifid, petiolate; segments opposite, sessile, linear, acute, glabrous, light green, one-nerved.

### *Calendula officinalis*, L.

*Achene* polymorphic—those of the ray incurved, in two to three series, varying greatly in length and outline, muricate on the back, pubescent, the outermost ones often narrow and greatly elongated or drawn out into a beak, and more or less produced into a hooklike appendage at the base. The next set within this is similar but furnished with broad wings, which are involute at the margin and more or less pubescent as well as muricate; the inner ones are strongly incurved, often forming a complete ring, narrowly winged with the wings involute at the margin, or wingless, short, muricate at the back, smooth on the ventral face, with the hooklike appendage still present at the base.

*Seed* terete or oblanceolate, and tapering to the base, more or less compressed dorso-ventrally, and conforming to the outline of the achene, glabrous; testa thin, pale, membranous; hilum and micropyle inferior, contiguous; chalaza apical, superior.

*Endosperm* absent.

*Embryo* large and filling the entire seed, colourless, more or less curved in conformity with the achene and seed; cotyledons spatulate, obtuse, entire, or the outer dorsal one sometimes minutely emarginate, tapering into the radicle and lying in the broader diameter of the seed with their backs to the axis or centre of the disc, plano-convex, subfleshy; radicle tapering to an obtuse point, lying in the narrow basal part of the seed, about half the length of the cotyledons or less.

### Germination.

#### A. The outermost achenes of the capitulum.

The radicle pushes out at the base of the fruit, and the energy of the swelling cotyledons is sufficient to split the achene into two or three valves longitudinally, that is, dorso-ventrally, or along the back and along the front on either side of the basal hook-like process. The hypocotyl has then no difficulty in extricating the cotyledons. If moderately covered with soil during germination, the seed is so loaded owing to the extent of its superficial area, that

it is rarely carried up on the cotyledons. The cotyledons when they emerge are oblong, obtuse, entire, and narrowed to the base. Of twelve fruits of this series sown, seven germinated, or 58·3 per cent.

B (fig. 477). The achenes from the middle series of the capitulum are more or less broadly winged. The radicle pushes out at the base of the fruit apparently most frequently on the ventral aspect, and not being able to get clear of the infolded margin of the wing, runs along the groove, and emerging at the apical end of the achene enters the soil, fixing down the achene while the hypocotyl pulls the cotyledons out. The achene splits longitudinally as in outer fruits of the receptacle into three valves, and seems to be rarely, if ever, carried up by the cotyledons. The figure shows the seedling two days after germination commenced.



FIG. 477.  
*Calendula*  
*officinalis*,  $\times 1\frac{1}{2}$ .  
Germination.

Of twelve fruits sown, nine germinated, or 75 per cent.

C. The innermost achenes of the capitulum are much curved. In germination they become deeply split, and the hypocotyl in elongating and straightening pulls the cotyledons out. The achene is sometimes carried up on the cotyledons, which immediately after emergence are narrowly spatulate-oblong, obtuse, entire, narrowed to the base, glabrous, pale yellowish-green. Of twelve fruits of this series, nine germinated, or 75 per cent.

#### *Calendula hybrida*, L.

*Achene* dimorphic, obovate-oblong, flattened and furnished with a broad membranous wing, or scarcely flattened and wingless with rows of teeth.

*Seed* conforming to the shape of the fruit, exalbuminous, 8–10 mm. long; testa membranous, smooth; hilum inconspicuous.

*Embryo* straight, filling the whole seed, dirty grey; cotyledons linear, obtuse, entire, rather thick, closely adpressed, lying the broad way of the seed; radicle tapering downwards, subacute, much shorter than the cotyledons.

#### *Calendula pluvialis*, L.

*Achene* dimorphic, some winged, broadly obovate or subrotund, (including wings), considerably flattened, smooth and brown; the others wingless, obovate, scarcely flattened, tubercled, black.



*Seed* conforming to the shape of the fruit, 4–5 mm. long; testa thin, membranous; hilum inconspicuous.

*Embryo* straight, filling the seed, colourless; cotyledons linear or linear-oblong, obtuse, entire, closely adpressed, lying the broad way of the seed; radicle tapering to the base, acute.

***Calendula algarbiensis*, Boiss.**

*Achene* at least trimorphic; those of the outer whorl linear-oblong, straight or slightly curved, wingless, covered with glandular hairs, 5–5.5 mm. long, surmounted by a beak from 5–7 mm. in length.

The second whorl consists of curved fruits, often forming a complete coil, winged, the wings bent downwards, covered with about three rows of pointed tubercles, and slightly glandular-hairy, 3.5–4 mm. in diameter.

The third whorl consists of wingless coiled fruits, forming almost a closed curve 2.5–8 mm. in diameter, extremely rugose, without hairs.

The fourth whorl is similar to the third, but the fruits are much smaller, being about 1 mm. long, and the coil is not closed.

***Ursinia speciosa*, DC. (fig. 478).**

*Achene* cylindrical-clavate, somewhat curved about the middle and narrowed at the base, longitudinally ten-ridged with the ridges in five contiguous pairs, transversely and minutely rugose, brown, surmounted at the base with white cottony hairs, and surmounted by a paleaceous pappus consisting of five ovate, obtuse pieces, hyaline or white and penninerved, with a linear-lanceolate, acute, pale brown midrib.

*Seed* basal, erect, conforming in outline to that of the achene, prolonged at the base; testa membranous, pale, much thinner; hilum basal; chalaza apical.

*Endosperm* absent.

*Embryo* slightly curved, owing to the curve of the achene, large and filling the interior of the seed to which it conforms; cotyledons linear-spathulate, narrow, truncate at the apex or rounded, or incipiently emarginate; radicle tapered to a narrow or subacute point, a little shorter than the cotyledons.

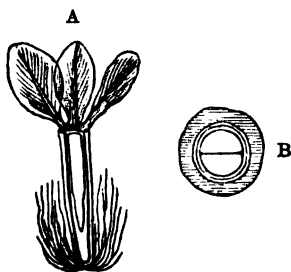


FIG. 478.—*Ursinia speciosa*. A, longitudinal section of achene,  $\times 2\frac{1}{2}$ . B, transverse section of achene,  $\times 5$ .

**Seedling.**

*Primary root* tapering downwards, wiry, flexuose, colourless, annual.

*Hypocotyl* ascending or erect, terete, glabrous, about 1.1 cm. long, purplish-green.

*Cotyledons* linear, obtuse, entire, fleshy, glabrous, persistent and green, 1.5 cm. long.

*Stem* herbaceous, annual, erect, angled, glabrous, pale green, shining; 1st internode 3.5 mm. long; 2nd 5.5 mm.; 3rd 1 mm.; 4th 1.4 cm.; 5th 5.5 mm.; 6th 1.65 cm.; 7th 1.45 cm.; 8th 1.85 cm.; 9th 1.45 cm.

*Leaves* simple, alternate (first two opposite), glabrous, deep green, fleshy, pinnatisect; petioles channelled above, convex or subcarinate beneath, the lower dilated and semiamplexicaul at the base, the upper amplexicaul, and auricled with a number of filiform, slender, acute laciniae.

Nos. 1 and 2. Opposite, pinnatisect, with two alternate pairs of lateral segments and a terminal one; all are linear and entire.

No. 3 and all above it. Alternate, pinnatisect; segments linear and entire, or slightly toothed.

No. 4. Pinnatisect; segments alternate and subpinnatifid.

No. 5. Pinnatisect, slightly auricled at the base; segments pinnatifid.

Nos. 6 and 7. Bipinnatisect, auricled at the base with slender laciniae; primary divisions of leaf oblong-linear in outline; secondary divisions narrow, small, subulate-lanceolate, suddenly pointed.

Nos. 8–10. Pinnatisect with linear, entire, cuspidate segments, channelled on the upper side, as are all the primary divisions of the leaves.

***Ursinia anthemoides*, Poir.**

*Hypocotyl* erect, terete, glabrous, 2–3 cm. long, light green or colourless.

*Cotyledons* very similar to those of *U. speciosa*, but subacute; indistinctly one-nerved.

*First leaves* pinnatisect, with a few scattered hairs; segments linear, acute.

*Stem* with the primary internodes undeveloped.

***Cryptostemma calendulaceum*, R. Br.**

*Primary root* tapering, flexuose, succulent, colourless, with fibrous lateral rootlets, annual.

*Hypocotyl* subterranean and with difficulty distinguishable from the root, stout, fleshy, and tapering downwards.

*Cotyledons* fleshy, oblong, obtuse, tapering into a short petiole, connate and amplexicaul at the base, 1.45 cm. long including petiole, 4 mm. wide above the middle, glabrous.

*Stem* undeveloped in the seedling stage, and always very short.

*Leaves* simple, radical, alternate, densely covered on the upper surface with short, jointed, crystalline hairs, woolly on the under surface; petioles flattened above or subchannelled, convex beneath, angled and furrowed, coarsely hairy or becoming woolly.

Nos. 1 and 2. Spathulate, irregularly and obsoletely dentate, tapering to both ends, subacute, with a strong median longitudinal nerve.

No. 3. Oblong, obtuse, repand-dentate, especially at the unsymmetrical base.

Nos. 4 and 5. Oblong, obtuse, lyrate-pinnatifid, unequal at the base; lateral lobes oblong, obtuse or cuspidate; terminal lobe large, oblong, somewhat lobed at the base and toothed upwards.

Ultimate leaves oblanceolate, deeply lyrate-pinnatifid, thinly woolly or subglabrous above, with a hoary tomentum beneath; lower lobes small, oblong, with small teeth; middle lobes broadly oblong in outline with small teeth on the anterior side, and larger on the posterior, and one large oblong, acute, basal lobe; terminal lobe large, broadly triangular, lobulate, coarsely dentate and denticulate.

***Venidium calendulaceum, Less.***

*Hypocotyl* erect, terete, glabrous, .5-2 cm. long, light green or colourless.

*Cotyledons* obovate, obtuse, emarginate, fleshy, slightly petiolate, glabrous, light green, almost colourless in some specimens, indistinctly one-nerved.

*Stem* short, erect, herbaceous; the primary internodes very slightly developed.

*First leaves* alternate, cauline, lanceolate, subacute, tapering to the base, scarcely petiolate, thickly pubescent with glandular hairs, entire, slightly ciliated, light green; with a midrib and two lateral nerves running parallel to the edges.

***Berkheya purpurea, Mast. (fig. 479).***

*Primary root* tapering, giving off a few lateral fibrils.

*Hypocotyl* short, mostly subterranean, purplish-red, rather succulent.

*Cotyledons* broadly obovate-oblong, entire, glabrous, 1.05 cm. long, about 9 mm. wide, amplexicaul.

*Leaves* simple, radical and cauline, alternate, sessile.

Nos. 1 and 2. Elliptical, irregularly spiny-serrulate with small prickles between the larger ones, pilose and bright green above, rather woolly and paler beneath, penninerved.

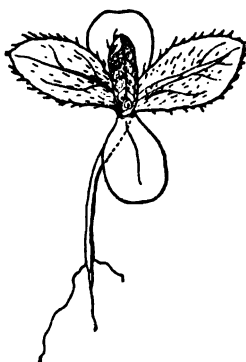


FIG. 479.  
*Berkheya purpurea*.  
Nat. size.

*Gundelia Tournefortii*, L.

*Hypocotyl* very stout, buried in the soil or rising from 8–15 mm. above it, emerging from one end of the fruit in germination while the radicle emerges from the other.

*Cotyledons* oblong, obtuse, entire and rounded at the base, and flat, or variously and unequally emarginate at the apex with a deep longitudinal channel or furrow along the centre or towards one side, and bluntly keeled beneath, fleshy, glabrous, with very difficultly discernible reticulate venation, sessile, connate at the base and forming a long sheath from whence the first leaf emerges while the plumule is still hidden, 2.5–3.2 cm. long, 1–1.5 cm. wide, (sometimes though rarely toothed near the apex). The furrow in the cotyledons is probably due to their being folded longitudinally in the seed.

*Leaves* simple, radical and cauline, alternate, exstipulate.

First leaf strap-shaped, involute at the base, where it emerges from the sheath of the cotyledons, thickly and unequally serrate with small spiny bristles or teeth; venation incurved and reticulate.

*Carduus giganteus*, Desf.

*Hypocotyl* very short, erect, terete, glabrous.

*Cotyledons* long, obovate-oblong, fleshy, obtuse, slightly emarginate, petiolate, glabrous, green, pinnatinerved.

*Stem* with the primary internodes undeveloped.

*Leaves* simple, cauline, alternate, petiolate, acute, spiny, hairy, light green, reticulate. The first two are lanceolate-elliptic.

*Cnicus diacanthus*, *Benth.* (fig. 480).

*Primary root* a fleshy, colourless taproot, with a few lateral fibres.

*Hypocotyl* succulent, suberect, terete, 1-2 cm. long, 2 mm. thick, quite glabrous, greenish-white, mostly subterranean.

*Cotyledons* connate, 2-2.5 cm. long, 1-1.25 cm. wide, obovate or spathulate, produced at the base, rounded at the apex, entire, with distinct midrib, quite glabrous, rather thick, yellowish-green above, paler beneath.

The stem is developed when about to flower.

The first three leaves are 5-8 cm. long, and 1 cm. wide, lanceolate, much narrowed to the base, acute at the apex, with three or more pairs of nerves springing from a broad sunk midrib, and terminating in setaceous

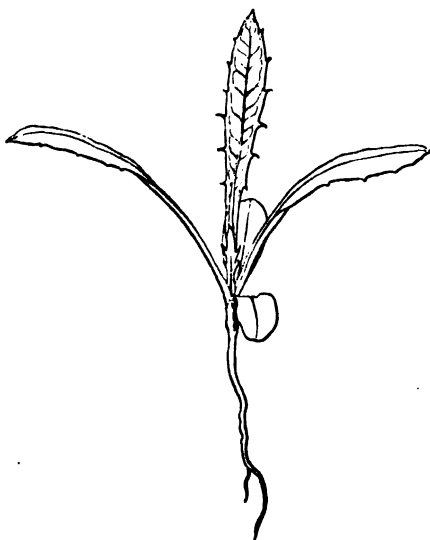


FIG. 480.—*Cnicus diacanthus*. Half nat. size.

teeth, and tomentose, especially on the under side, slightly succulent, bright green above, tomentose beneath.

Ultimate leaves simple, radical and cauline, alternate, sessile or the radical ones elongated into a petiole-like base, alternately incurvined, toothed, or lobed, or subpinnatifid, spiny, deep green above with silvery midrib and principal nerves, somewhat felted or cottony, colourless and tomentose beneath; radical ones dilated and sheathing at the base.

*Cnicus syriacus*, *Willd.*

*Primary root* very long, stout, tapering downwards, with short lateral rootlets, annual.

*Hypocotyl* very short, and hardly distinguishable from the root.

*Cotyledons* obovate, obtuse, slightly emarginate or nearly entire, tapering into the broad petiole, which is connate at the base, alternately and ascendingly penninerved, but venation discernible with difficulty, light green above with a purple midrib, much paler beneath, glabrous, 3.5–6.2 cm. long including the petiole, 2–2.5 cm. wide near the apex.

*Stem* erect, herbaceous, annual, developing when about to flower; primary internodes undeveloped.

*Leaves* radical and cauline, alternate (first pair opposite), nerves alternately incurving, strongly reticulate, and giving off short more slender branches into the marginal lobes or teeth, margin spiny, subsucculent, thinly hairy on both sides with soft, whitish, jointed hairs, deep green above, with a purple midrib, and marked with broad grey or whitish bands; petioles semiterete with broad shallow channels above which are generally purple with green margins, green beneath, thinly hairy or slightly woolly at the margins, dilated at the base and semi-amplexicaul or those of the first pair connate.



FIG. 481.—*Silybum Marianum*.  
Half nat. size.

Nos. 1 and 2. Elliptic, obtuse, margin unequally spiny-toothed.

Nos. 3–6. Elliptic or oblong-elliptic, very obtuse, lobulate and spiny-toothed.

***Silybum Marianum*,**  
*Gærtn.* (fig. 481).

*Primary root* long, tapering, fleshy, colourless, giving off lateral fibres, biennial.

*Hypocotyl* subterranean, stout and scarcely distinguishable from the root.

*Cotyledons* large, foliaceous, obovate-oblong, obtuse, tapering into the broad, flattened petiole, penninerved, nerves alternate; petiole about 1.7 cm.

long, connate and amplexicaul; lamina 2.6 cm. long, 1.8 cm. wide.  
*Stem* developed in the second year.

*Leaves* radical and cauline, alternate, petiole dilated and sheathing at the base, more or less hairy or villous at the margin and beneath, variegated on the upper surface with ascending and anastomosing, broad, milk-white veins on a bright green ground, paler green on the under side.

Nos. 1 and 2. Oval, obtuse, cuneate at the base, doubly spiny-toothed, sparsely setose on the upper surface, and villous on the midrib beneath.

Nos. 3 and 4. Oblong, obtuse, pinnatifid, cuneate at the base, doubly spiny-toothed. Otherwise like Nos. 1 and 2.

Ultimate leaves oblong-lanceolate, deeply pinnatifid, decurrent on the petiole and auricled at the base, woolly on the midrib and papillose on both surfaces, ultimately glabrous, bright green, reticulated with milky-white veins; lobes broadly deltoid, lobulate, and spiny-serrate, with a large spine terminating each lobe and large tooth.

***Tyrimnus leucographus*, Cass.**

*Primary root* strong, tapering downwards, normal, annual.

*Hypocotyl* short or hardly developed.

*Cotyledons* oblong, obtuse, entire, tipped with a pale gland, sub-fleshy with a strong midrib and indistinctly discernible, alternate, ascending nerves finely but very indistinctly reticulate, tapering at the base into a short broad petiole which is connate with the other one, glabrous, shining on both surfaces, light green above, paler beneath, 1·8-2·2 cm. long including the petiole, 9-10·5 mm. wide.

*Stem* erect, annual, developed when about to flower, and winged by the decurrent bases of the leaves; primary internodes undeveloped.

*Leaves* simple, radical and cauline, alternate, a few of the primary leaves petiolate, the rest sessile; nerves alternate and incurving, strongly reticulate; thinly hairy on both surfaces, with soft, whitish, jointed hairs, bright green, shining, and irregularly blotched with white markings on the upper surface, uniformly pale green, almost glaucous beneath; petioles of first few leaves very short, flat above, convex on the back, thinly hairy.

Nos. 1 and 2. Oval, obtuse, shortly petiolate, irregularly and minutely spiny-toothed.

Nos. 3-5. Oblong, or oblong-obovate, lobulate, and irregularly spiny-toothed.

Cauline leaves sinuately lobate or pinnatifid, irregularly spiny-toothed, decurrent on the stem, forming wings.

***Centaurea Clementei*, Boiss. (fig. 482).**

*Primary root* pale yellowish, stout or fleshy, tapering, with short stout lateral rootlets.

*Hypocotyl* stout, glabrous, cylindrical, red above ground and yellowish beneath, 1.8 cm. long, 2.25 mm. thick.

*Cotyledons* foliaceous, spatulate, obtuse, entire, tapering into the petiole which is dilated and connate with the other one at the base, 3.9 cm. long including the petiole, 1.1 cm. wide near the top, pale green, glabrous.



FIG. 482.—*Centaurea Clementei*.  
Half nat. size.

*Stem* herbaceous, elongating when about to flower.

*Leaves* radical and ultimately also cauline, alternate, whitish and cottony on both sides, especially when young; petioles slightly channelled on the upper side, dilated and sheathing at the base.

No. 1. Spathulate, acute, entire.

No. 2. Ovate, sub-acute, unequally dentate-serrate (deformed in specimen described).

No. 3. Oblong-elliptic in outline, acute, pinnatifid; lower segments small, usually unequal; middle segments larger, ovate, acute, with a strong nerve running into them; terminal segment much the largest, oblong-ovate, trinerved, more or less serrate.

No. 4. Similar but more deeply cut.

***Centaurea ragusina*, L.**

*Hypocotyl* 8–14 mm. long, 1–1.5 mm. thick, pale green, almost wiry in texture.

*Cotyledons* as in *C. Clementei*.

*Stem* herbaceous, very short.

*Leaves* radical and cauline, alternate, petiolate.

No. 1. Spathulate, obtuse or apiculate, entire, thinly tomentose on both sides, pale green or nearly colourless, thick and soft; petiole 4 mm. long, slightly channelled above.

No. 2. Similar, whiter and more tomentose.

Succeeding forms are gradually larger, spatulate, entire or



slightly dentate; then oblong-ovate, obtuse, cuneate at the base, more or less irregularly dentate.

Ultimate leaves oblong, petiolate, lyrate-pinnatifid, felted on both surfaces with a dense white tomentum; terminal segment ovate or triangular-ovate, large, pinnatifid at the base and toothed upwards; lateral segments alternate or subopposite, spathulate-oblong, narrowed to an obtuse point, entire.

***Mutisia ilicifolia*, Hook. (fig. 483).**

*Hypocotyl* extremely short, hardly appearing above the ground, almost square, downy.

*Cotyledons* ovate, thick, fleshy, acute, recurved, with their points penetrating the ground, glabrous, dark green, indistinctly nerved, with short petioles.

*Stem* erect, herbaceous, almost square, thickly covered with down; 1st internode very short; 2nd longer.

*First leaves* simple, cauline, alternate, ovate with a cordate base, toothed or spiny, sessile, clasping the stem, glabrous, light green, with a distinctly reticulate venation. The buds are covered with a thick white down.



FIG. 483.—*Mutisia ilicifolia*.  
Half nat. size.

***Mutisia copiapina*, Auct.**

*Hypocotyl* erect, terete, 7.5–10 mm. long, hoary, greenish, or stained with red.

*Cotyledons* oblong or slightly ovate, large, from 3.5–4 cm. long, ascending, otherwise as in last species.

*Stem* short, erect, terete, glabrous, light green; 1st internode 1–2 mm. long; 2nd shorter.

*Leaves* oblong, otherwise as in the last species.

In an abnormal specimen one of the cotyledons was divided down to the base, forming two linear leaves, giving the plant the appearance of having three cotyledons.

***Ainsliea fragrans*, Champ.**

*Hypocotyl* rather succulent, 5–10 mm. long, 1 mm. thick, terete, glabrous, reddish.

*Cotyledons* shortly stalked, 1.5 cm. long, 5–7 mm. wide, ovate-

oblong, cuneate at the base, with an obtuse apex, entire, glabrous, obscurely nerved and dull greenish-grey above, bronzed beneath, with distinct midrib and two long nerves running just within the margin, thin.

*Leaves* radical and cauline, alternate, with the principal nerves of the radical leaves radiating from the base of the blade and incurved, hairy; cauline small; petiole semiterete, hairy.

Nos. 1 and 2. Roundly cordate, cuspidate or mucronate, pubescent and hispid, with bristly upcurved teeth at the margin and a pubescent petiole.

***Gerbera lanuginosa*, Benth. (fig. 484).**

*Primary root* normal, tapering, flexuose, branching.

*Hypocotyl* short, colourless, succulent, 2 mm. long.

*Cotyledons* oblong, obtuse, 8-10 mm. long, 4 mm. wide; petiole channelled above, convex beneath, 7 mm. long.

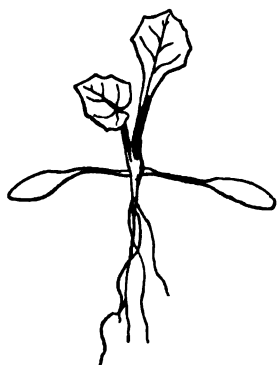


FIG. 484.  
*Gerbera lanuginosa*.  
Nat. size.

*Leaves* simple, radical, alternate, glabrous above and felted with white tomentum beneath, decurrent on the petiole; petioles dilated and sheathing at the base, deeply channelled above, glabrous, except where the lamina is decurrent, woolly in the adult.

No. 1. Roundish-rhomboid, cuneate at the base, subrepand-denticulate, teeth almost reduced to mucros.

No. 2. Rotund-cordate, acute, repand-denticulate, with mucronate teeth.

Ultimate leaves lyrate-pinnatifid, oblong-obovate in outline, petiolate, glabrescent above, felted beneath with white tomentum; lateral lobes alternate, short, rounded, becoming very much smaller towards the base; terminal one much the largest, oblong, obtuse, distantly and mucronately dentate, frequently truncate at the base, very short and broad; petioles channelled above, woolly.

***Leuceria senecioides*, Hook. et Arn.**

*Hypocotyl* erect, terete, finely pubescent, 1-1.5 mm. long, light green or colourless.

*Cotyledons* subrotund, emarginate, obtuse, fleshy, petiolate, green, very indistinctly pinnatinerved; petioles and margin with a few short hairs, otherwise glabrous.

*Stem* with the primary internodes undeveloped.

*First leaves* simple, cauline, alternate, sinuate, subacute, obovate-oblong, petiolate, finely pubescent, light green, pinnatinerved, with alternate or subopposite, obtuse or acute lobes.

*Moscharia pinnatifida*, Ruiz et Pav.  
(fig. 485).

*Achene* enclosed in an oblique or subcarinate bract, which springs from the receptacle and entirely surrounds it; obovate, suboblique, with a short pappus of feathery unequal hairs springing apparently from one corner and fitting into the cavity of the receptacular bract.

*Seed* obovoid, obtuse at both ends, brown, smooth, small; hilum basal; chalaza apical.

*Endosperm* absent.

*Embryo* obovoid, fleshy, colourless, filling the cavity of the seed, straight; cotyledons plano-convex, closely applied face to face, minutely emarginate; radicle subturbinate, stout, obtuse, short, close to the hilum.

*Moscharia rosea*, Ruiz et Pav. (fig. 486).

*Primary root* vertical, slender, colourless, with a few fibres.

*Hypocotyl* succulent, about 1 cm. long, 1.5 mm. thick, terete, pubescent, colourless.

*Cotyledons* oblate, 6 mm. long, 8 mm. wide, retuse or emarginate at the apex, obscurely nerved, pubescent, thin, yellowish-green; petioles about 8 mm. long, 1.5 mm. wide, connate, pubescent.

*Stem* short, succulent, pubescent and reddish when quite young.

The first leaf is lyrate pinnatifid, penninerved, pubescent, thin,

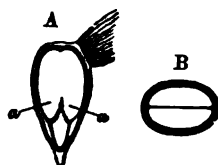


FIG. 485.—*Moscharia pinnatifida*. A, longitudinal section of achene, showing embryo,  $\times 8$ . B, transverse section of achene,  $\times 8$ .

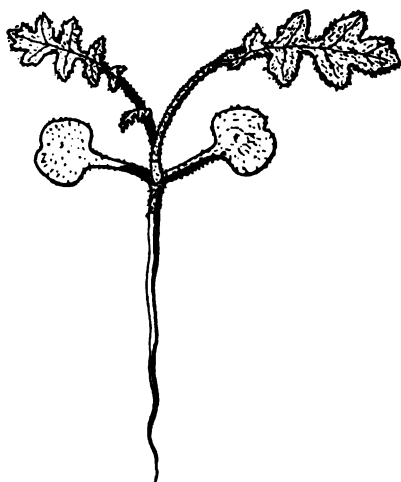


FIG. 486.—*Moscharia rosea*. Nat. size.

including the long pubescent petiole about 8 cm. long, nearly 1 cm. wide, yellowish-green. The next two are similar.

Ultimate leaves simple, radical, and cauline, alternate, petiolate or sessile, alternately penninerved, pinnatifid, hairy; petiole of the radical leaves semiterete, hairy, dilated and sheathing at the base.

***Microseris Bigelovii*, A. Gray.**

*Primary root* annual, tapering, slender and branched.

*Hypocotyl* glabrous, terete, red, 9–12 mm. long, tapering into and hardly distinguishable from the root.

*Cotyledons* linear, slender.

*Stem* herbaceous, annual, erect, terete, thinly glandular-hairy, reddish or purplish; 1st internode .5–1 mm. long; 2nd about 1 mm.

*Leaves* simple, cauline, alternate, sessile, sheathing at the base, and ciliate there with white hairs, especially on the sheathing part.

Nos. 1–6. Linear, entire, acute, shallowly channelled above, slightly keeled beneath, and very slightly widened above the middle, so that they do not greatly differ from the cotyledons.

***Rhagadiolus stellatus*, DC.**

*Achene* almost enclosed by a partially lignified bract; lanceolate or subulate, straight or curved, prolonged into a beak, or in others crowned by a pappus.

*Seed* conforming in shape to the fruit, somewhat laterally flattened or terete; testa smooth; hilum inconspicuous.

*Embryo* straight, filling the whole of the seed; cotyledons linear, obtuse, entire, yellowish-white, plano-convex, closely adpressed face to face, sessile, lying the broad way of the seed, with their edges to the axis of the disc; radicle short, terete, much shorter than the cotyledons, obtuse.

**Seedling (fig. 487).**

*Primary root* long, slender, tapering, giving off numerous lateral rootlets, annual.

*Hypocotyl* short, stout, fleshy, passing into the root.

*Cotyledons* oblong-spathulate, obtuse, glabrous, 1.5 cm. long; petiole flattened above, scarcely channelled, 1 cm. long.

*Stem* annual, developed when about to flower.

*Leaves* simple, radical, ultimately cauline, alternate, light green, rather coarsely hairy, especially on the under side and the petioles;

petioles short or none, winged for a great part by the decurrent lamina, flattened above, dilated at the base.

No. 1. With a short, broadly elliptic lamina, decurrent nearly to the base of the petiole, obsoletely, distantly, and mucronately dentate.

No. 2. With a rotund lamina decurrent on the petiole; wing with a few deltoid mucronate teeth.

Nos. 3-6. Irregularly runcinate; terminal segment rotund, obsoletely, mucronately dentate; lateral segments of Nos. 3 and 4 deltoid, mucronate, decurved; lateral segments of Nos. 5 and 6 broadly oblong, mucronate, obtuse, subdecurved.

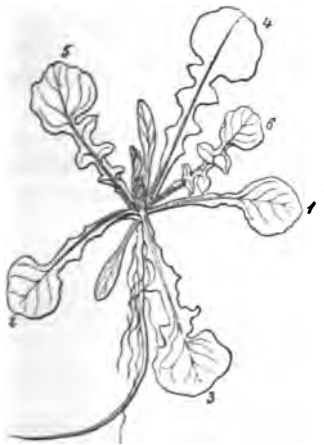


FIG. 487.—*Rhagadiolus stellatus*.  
Half nat. size.

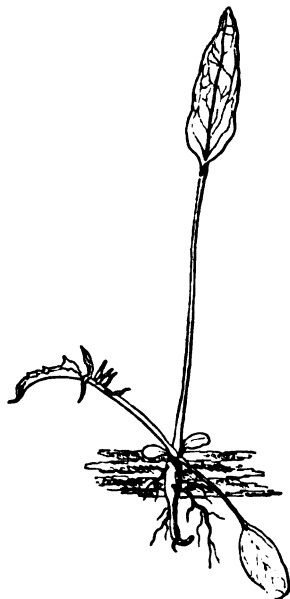


FIG. 488.—*Lactuca lævigata*.  
Half nat. size.

***Lactuca lævigata*, DC. (fig. 488).**

*Primary root* a short, stout, fleshy or tuberous taproot, colourless, giving off numerous lateral branching fibres.

*Hypocotyl* subterranean.

*Cotyledons* spatulate, obtuse, entire, glabrous, 8 to 10 mm. long.

*Leaves* radical, alternate, glabrous, with petioles sheathing at the base.

No. 1. Oval, obtuse, entire, cuneate at the base, obscurely penni-

nerved and reticulate, pale green above, glaucous beneath ; petiole terete, slender, pale green mottled with purple, sheathing at the base.

No. 2. Lanceolate, obtuse, entire, five-nerved and reticulate, deep green above, glaucous beneath ; petiole terete, pale green, closely mottled and streaked with purple, sheathing at the base.

No. 8. Lyrate-pinnatifid of seven segments ; segments linear, obtuse or subacute, glaucous-green suffused with purple, the lowest pair smallest ; terminal segment much the largest, oblong-lanceolate, obtuse, irregularly serrate, penninerved and reticulate, glaucous-green suffused with purple, glaucous beneath ; petiole terete, pale green mottled and streaked with purple.

***Sonchus squarrosus*, DC.**

*Hypocotyl* erect, terete, glabrous, 1-1.5 mm. long, light green or colourless.

*Cotyledons* oblong-obovate, obtuse, emarginate, petiolate, glabrous, light green, pinnatinerved like the leaves.

*Stem* herbaceous, erect ; primary internodes undeveloped.

Primary leaves simple, alternate, subrotund, obtuse, dentate-serrate, with a few scattered bristly hairs above, glabrous beneath, light green with a faint tinge of violet, pinnatinerved.

***Sonchus arvensis*, L.**

*Leaves* simple, ultimately more or less pinnatifid and spiny-toothed, thinly glandular-hairy or pubescent on both surfaces, at least in the seedling stage.

No. 1. Obovate-spathulate, entire, 1.7 cm. long.

Nos. 2 and 3. Oblanceolate-spathulate, irregularly spiny-denticulate.

No. 4. Spathulate, subdecurent on the petiole, with margin undulate, spiny-toothed.

No. 5. Spathulate-oblong, margin undulate, spiny-toothed.

No. 6. Linear-oblong, sessile, broadest near the tip, tapering to the base, irregularly doubly spiny-toothed.

No. 7. Linear-oblong, lobulate and spiny-toothed, margin undulate, sessile, tapering to the base.

Nos. 8 and 9. Linear-oblong, subpinnatifid with undulate, spiny-toothed lobes.

***Zollikoferia* sp.**

*Hypocotyl* erect, terete, glabrous, 6-10 mm. long, light green or colourless.

*Cotyledons* spatulate-obovate, obtuse, slightly emarginate, glabrous, light green, indistinctly trinerved.

*Stem* with the primary internodes undeveloped.

*First leaves* simple, cauline, alternate, or in some plants the first pair are opposite, dentate, oblong-obovate, obtuse, petiolate, glabrous, light green, reticulate.

*Tragopogon crocifolium*, L.

*Hypocotyl* erect, terete, glabrous, 8-10 mm. long, tinged with red.

*Cotyledons* long, linear, acute, clasping the stem, sessile, glabrous, light green, one-nerved like the first leaves.

*Stem* with primary internodes undeveloped.

*First leaves* simple, entire, radical, alternate, linear, narrow, acute, light green, glabrous, one-nerved.

## STYLIDIEÆ.

Benth. et Hook. *Gen. Pl.* ii. 534.

*Fruit and Seed*.—The ovary is inferior and two-celled, or one-celled at the very base. The ovules are very numerous in each cell, attached to the middle of the axile placentas and anatropous. The fruit is capsular and two-celled, or one-celled by the disappearance of the dissepiment, generally dehiscent by two valves parallel to the septum, more rarely indehiscent. The seeds are numerous, rarely solitary by abortion, and always small with a membranous testa and a fleshy endosperm. The embryo is minute, embedded in the endosperm, with the radicle close to the hilum.

The species of *Levenhookia* have generally a one-celled ovary with a few seeds arising from a basal placenta and more or less attached to the side walls.

*Seedlings*.—This Order is a small one, containing about one hundred species or slightly fewer, of which the typical genus *Stylidium* numbers about eighty-four, of various habit but always herbaceous, and often with small densely arranged leaves somewhat resembling a Heath. *S. adnatum* (fig. 489) is the only species observed. The cotyledons are



FIG. 489.  
*Stylidium*  
*adnatum*,  $\times 8$ .

small, obovate, minutely cuspidate, sessile, tapering to the base and slightly connate. The leaves are somewhat similar, but narrower and densely arranged.

*Stylidium adnatum*, R. Br. (fig. 489).

*Primary root* tapering downwards, flexuose, slender, with slender lateral rootlets, perennial.

*Hypocotyl* erect, terete, more or less rough, with little tuberculated elevations, pale flesh-coloured or colourless, 6.5–11 mm. long.

*Cotyledons* obovate, obtuse, indistinctly petiolate, entire, minutely cuspidate, glabrous, light green, with a difficultly discernible midrib, 2.75–3.5 mm. long including the petiole-like base, 1.75–2 mm. wide.

*Stem* erect, subterete or obtusely angled, glabrous, but roughened with numerous small colourless elevations, leafy; 1st and 2nd internodes undeveloped; 3rd very variable, 2–6 mm. long; the rest generally very short with the leaves close together.

*Leaves* simple, entire, cauline, alternate (the first two opposite, decussating with the cotyledons), exstipulate, petiolate, with a midrib, but no other discernible venation in the fresh state, scaberulous or minutely ciliate at the margin with colourless hairs or short points, otherwise glabrous, light green; petiole biconvex, narrowly channelled above, thickened at its insertion on the stem, short, glabrous, pale green.

Nos. 1–30. All similar, small, spathulate or oblanceolate, minutely cuspidate, narrowed into the petiole, very numerous and closely aggregated.



## CAMPANULACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 541.

*Fruit and Seed.*—The ovary is inferior or half, rarely wholly superior, and generally 2–5-, rarely 6–10-celled, and consisting of as many carpels; a one-celled condition is rare and then probably occurs through the abortion of one out of two carpels, or more generally by the disappearance of the septa during growth. The placentas are mostly axile, sometimes attached to the middle of the septa where they become stalked or peltate. The ovules are numerous, rarely two, and attached either at the top or base of the cell, erect, horizontal, or pendulous and anatropous. The fruit is capsular or baccate, dehiscing variously by pores or valves beneath or above the calyx-limb, or indehiscent and liberating the seeds by decay. The seeds are mostly very small and numerous with a membranous or leathery testa. The embryo is also minute and embedded in the axis of the endosperm with the radicle close to the hilum.

Exceptions occur in species of *Lysipoma*, *Clermontia* and *Delissea*, which have a one-celled ovary with parietal placentas, but even here these conditions are very rare. In *Merciera* the one-celled ovary has a pair of basal erect ovules; and in *Siphocodon* the ovary is three-celled, but the ovules are suspended from the apex of the cavities. Baccate fruits occur in *Pratia*, *Colensoa*, *Rollandia*, *Cyanea*, *Delissea*, *Clermontia*, and others both of the tribes *Lobeliæ* and *Campanulæ*.

*Seedlings.*—Amongst the seedlings observed are three different types of cotyledons, namely, subulate, ovate, and rotund or suborbicular, frequently emarginate. As the embryo is very small while yet in the seed, the ultimate form of the cotyledons is due to growth or development during and after germination.

The subulate type may be represented by *Downingia pulchella* (fig. 490). The cotyledons are subulate-linear, 6–7 mm. long, and precisely similar to the first pair of leaves. The upper leaves become gradually wider and 3–5-nerved. The ovate type is fairly represented by *Lobelia Erinus* (fig. 492).

Although very small they are mostly if not always slightly emarginate and shortly petiolate, not only in this species but the whole group. The first two leaves of *L. Erinus* are ovate or elliptic with slender petioles. The cotyledons of *Lobelia tenuior* are much larger, ovate, and emarginate with longer petioles. The first two leaves are rhomboid, while the third is shallowly five-lobed.

Another type is furnished by *Campanula bononiensis* (fig. 498). The cotyledons resemble those of *Lobelia tenuior*. The first leaf is spatulate-ovate, the second oval, and the third and fourth obovate. The cotyledons of *C. thyrsoides* are smaller, and the first leaf is also relatively small, ovate, and obscurely dentate. Succeeding leaves vary through ovate, oval, obovate and elliptic forms, at the same time greatly increasing in size, and much exceeding in that respect any of the above mentioned.

Suborbicular and emarginate cotyledons are met with in *Campanula gummifera*. They are also more markedly reticulate than is generally the case. The first leaf is cordate, crenate, and hairy. The cotyledons of *Specularia castellana* are emarginate and rather broader than long. Three or four of the primary leaves are suborbicular, shallowly crenate and hairy. The seedling of *Colensoa physaloides* (fig. 491) recalls that of *Campanula thyrsoides* to some extent in its small entire cotyledons and the graduation of the leaves from the first small one to the fifth, and onwards. The internodes are, however, much more elongated. A slightly different type occurs in *Specularia biflora* which has comparatively large oblong-obovate emarginate cotyledons tapering into a long petiole.

The first four leaves are obovate-spathulate, and obscurely crenate, with glands in the notches, not on the crenatures.

### ***Downingia pulchella*, Torr. (fig. 490).**

*Primary root* slender, colourless, soon giving rise to a fascicle of strong colourless roots from its base.

*Hypocotyl* herbaceous, strong, erect, terete, glabrous, 1.5–2.2 cm. long and 1 mm. thick, or more.

*Cotyledons* subulate-linear, slender, acute, deep green and

shining, 6-7 mm. long, precisely similar to the first four pairs of leaves.

*Stem* herbaceous, erect, stout, glabrous, green; internodes short; 1st 4-5 mm. long; 2nd 2.5-3 mm.

*Leaves* simple, entire, cauline, alternate (lower opposite), exstipulate, glabrous, slender at least in the young plant.

Nos. 1-8 or 10. In decussate pairs, linear-subulate, acuminate, and showing a midrib only.

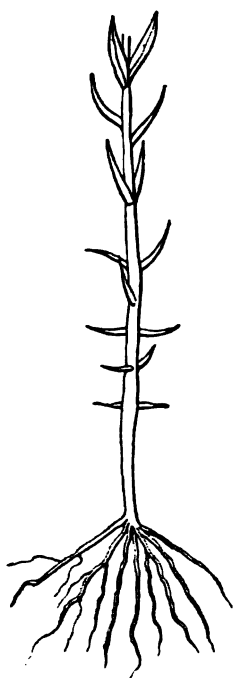


FIG. 490.—*Downingia pulchella*.  
Nat. size.



FIG. 491.—*Colensoa physaloides*.  
Nat. size.

Above this they are gradually broader, and three- to five-nerved from the base.

*Colensoa physaloides*, Hook. f. (fig. 491).

*Primary root* densely fibrous.

*Hypocotyl* 5 mm. long, 1.5 mm. thick, terete, herbaceous, glabrous, usually purplish-green.

*Cotyledons* 4-5 mm. long, 2.5-3 mm. wide, broadly petiolate,

suborbicular, entire, glabrous, very obscurely nerved, dark dull green above, paler beneath.

*Stem*.—1st internode 1–2 mm. long, and as thick; 2nd–4th about 5 mm. long, ridged owing to the decurrent petioles of the leaves.

*Leaves*.—No. 1. About 1 cm. long including petiole, 5 mm. wide, elliptic, oblique, acute, slightly serrate, penninerved, glabrous except a few hairs on lower side of the petiole and midrib, thin, slender, dull green.

Nos. 2–5. More deeply mucronate-serrate.

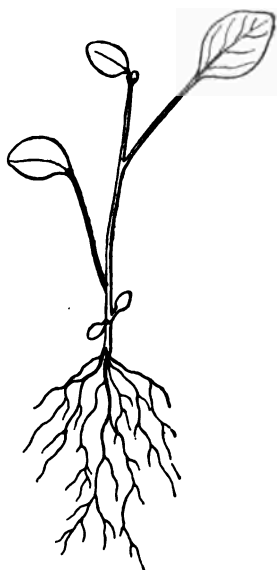
Ultimate leaves simple, cauline, alternate, exstipulate, petiolate, alternately incurvinerved, reticulate, glabrous or nearly so, simply or doubly serrate.

***Lobelia Erinus*, L. (fig. 492).**

*Primary root* fibrous, slender, colourless.

*Hypocotyl* 5 mm. long, 1 mm. thick, terete, slender, colourless.

*Cotyledons* 4 mm. long including the short petiole, 2.5 mm. wide, ovate, slightly emarginate, cuneate at base, glabrous and very obscurely nerved, light green.



*Stem*.—1st internode 5 mm. long, 1 mm. thick; 2nd 1.5–2 cm. long, slender, terete, glabrous, almost colourless.

The two first leaves are like the cotyledons but larger; petiole, 1.5–2 cm. long, .75 mm. wide, glabrous; blade 1 cm. long, nearly as wide, entire.

The second is often serrate-crenate near the base, penninerved, with a few hairs on the petiole.

Ultimate leaves simple, cauline, alternately penninerved, glabrous or slightly hairy on the petiole, thin, membranous, with milky juice, deep green; petiole slender, rather brittle.

FIG. 492.—*Lobelia Erinus*.  
Nat. size.

***Lobelia tenuior*, R. Br.**

*Primary root* as in *L. Erinus*.

*Hypocotyl* erect, terete, glabrous, purple above ground, colourless beneath, 2–2.6 cm. long.

*Cotyledons* ovate, obtuse, emarginate, glabrous, stained with

purple; lamina 3-8.5 mm. long, 2-8 mm. wide, with indistinct venation; petiole slightly flattened above, the two sometimes slightly alternate, 2.5-4 mm. long.

*Stem* herbaceous, erect, at least in the seedling stage, terete, striated, glabrous with the exception of some lines of hairs running down from the decurrent bases of the leaves, stained with purple; 1st internode 3-4 mm. long; 2nd 2-3 mm.

*Leaves* glabrous, with ascending nerves running into the teeth or lobes; petiole flattened or slightly channelled above, rough on the back and margin.

No. 1. Rhomboid, obtuse, obsoletely dentate at the margin.

No. 2. Larger, similar, but with five blunt teeth.

No. 3. Shallowly five-lobed.

*Campanula bononiensis*, L. (fig. 498).

*Primary root* vertical, small, slender, colourless, with a few fibres.

*Hypocotyl* 2-2.5 cm. long, .7 mm. thick, terete, glabrous, nearly colourless.

*Cotyledons* nearly equal, about 7 mm. long, 3-4 mm. wide, shortly stalked, ovate, cuneate at the base, obtusely emarginate, obscurely nerved, entire, glabrous, light green.

*Stem* herbaceous, erect, terete, hairy; 1st internode 3.5 mm. long.

*Leaves* simple, radical and cauline, alternate, exstipulate, petiolate, hairy on both sides, but chiefly on the margins and the nerves beneath; petioles channelled above, convex beneath, dilated and amplexicaul at the base, coarsely hairy.

No. 1. Spathulate-obovate, entire.

No. 2. Oval, obtuse, tapering to the base, obsoletely crenate-serrate.

Nos. 3 and 4. Obovate, obtuse, serrate-crenate, subreticulately veined.

*Campanula gummifera*, Willd.

*Hypocotyl* glabrous, 6-10 mm. long, light green or colourless.

*Cotyledons* ovate-rotund, slightly emarginate, obtuse, petiolate, glabrous, light green, indistinctly pinnatinerved like the leaves.

*Stem* with primary internodes undeveloped.

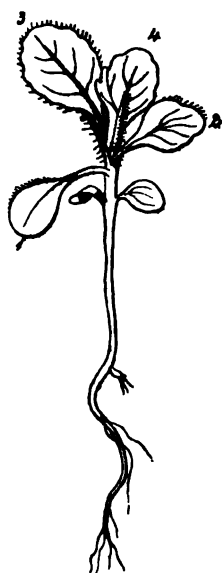


FIG. 498.  
*Campanula bononiensis*.  
Nat. size.

*First leaves* simple, radical, alternate, cordate, crenate-serrate, hairy with rather long stiff hairs, green, pinnatinerved; petiole long, furrowed above.

***Campanula thyrsoidea*, L.**

*Primary root* tapering, twisted or flexuose near the top, and giving off numerous lateral fibres, biennial.

*Hypocotyl* subterranean, short, stout, fleshy, colourless, glabrous, 5 mm. long.

*Cotyledons* small, ovate, obtuse, subpetiolate, 3.5 mm. long, 2.5 mm. wide, hairy.

*Stem* herbaceous, developed when about to flower.

*Leaves* radical and cauline, sessile (or the first two to four shortly petiolate), light green and shining above, paler and shining beneath, densely hairy on both surfaces, penninerved with alternate nerves; petioles of first four leaves, short, broad, flattened above.

No. 1. Ovate, obtuse, slightly dentate, 7.5 mm. long, 5 mm. wide.

No. 2. Similar, larger.

No. 3. Oval, obtuse, serrulate; cuneate at the base.

No. 4. Ovate, obtuse, cuneate at the base, serrulate.

No. 5. Elliptic, obtuse, serrulate, cuneate at the base and sessile.

No. 6. Oblong-elliptic, obtuse, serrulate, cuneate at the base, sessile.

No. 7. Obovate, obtuse, crenate-serrate.

Nos. 8 and 9. Oblong-elliptic, obtuse, crenate-serrate.

*Ultimate leaves* obovate-spathulate, subacute, tapering to the base, mucronately serrulate, bright green, shining and hairy above especially towards the margin, paler beneath, shining and nearly glabrous, flat or concave.

***Specularia castellana*, Lge.**

*Hypocotyl* erect, terete, glabrous, 1.4–1.8 cm. long, light green, or colourless.

*Cotyledons* ovate-rotund, small, emarginate, glabrous, green, indistinctly one-nerved; petioles rather broad, very slightly channelled on the upper face.

*Stem* with primary internodes undeveloped.

*Primary leaves* broadly oblong or subrotund, radical, alternate, obtuse, crenate, finely pubescent, green, pinnatinerved; with broad hairy petioles, channelled above.

***Specularia biflora*, A. Gray.**

*Primary root* long, with short lateral fibres.

*Hypocotyl* 2-2.5 cm. long.

*Cotyledons* oblong-obovate, 5-6.5 mm. long, 4-4.5 mm. wide; tapering into the long petiole, which is slightly channelled above, 9-11 mm. long.

*Stem* erect, terete, striate, pubescent, herbaceous, twisted; 1st internode 1 cm. long; 2nd longer.

*Leaves* thinly pubescent, tapering into and slightly decurrent on the petiole which is channelled above, venation reticulate but very indistinct.

Nos. 1-4. Obovate-spathulate, obtuse, obsoletely crenate, with glands in the notches, and in the apical one when the leaf is emarginate.

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**ERICACEÆ.**

Benth. et Hook. *Gen. Pl.* ii. 577.

*Fruit and Seed*.—The ovary is superior and consists of two to twelve carpels united so as to form as many cells; the union may be complete or the carpels may be partly free at the top, making the ovary lobed as occurs in many of the Rutaceæ and Labiatae. The ovules are numerous and inserted on axile placentas, or suspended from the apex of the cells and anatropous; they rarely ascend from the base of the cells. The fruit is capsular, rarely baccate as in *Arbutus* and *Pernettya* or drupaceous as in *Arctostaphylos*, and dehisces loculicidally or septicidally by as many valves as there are carpels, or the carpels may break away from the axial placentiferous column. Fruits breaking up into cocci are very rare. The seeds vary from one to many, but they are usually minute and very numerous, angled or compressed, with a closely fitting or sometimes a loose testa prolonged at either end. The embryo is embedded in a fleshy endosperm, with short cotyledons and a rather elongated radicle.

*Seedlings*.—The seeds are minute in most cases, and the cotyledons generally small. The seedlings of *Rhododendron arboreum* (fig. 494) and *Erica Tetralix* represent therefore the more typical forms of the Order. The cotyledons of *Rhodo-*

dendron arboreum are small, oval and pubescent. The two primary leaves are also oval, but several times larger. The ultimate ones are oblong-lanceolate, entire, and attain a length of six to nine inches. The genus *Erica* is represented by *E. Tetralix* which has minute oval cotyledons, and always very small leaves. In a seedling observed the first pair of leaves were opposite, followed by four whorls of three each, above which were a few scattered ones, those again followed by whorls of four leaves each as in the adult plant. In the seedling they are flat, in the adult strongly revolute at the margins.

A curious type occurs in *Enkianthus japonicus*, the cotyledons of which are oblong-ovate and crenulate, as in *Ptelea trifoliata* amongst the Rutaceæ. The first four leaves are elliptic and serrulate. Another unusual form occurs in *Clethra arborea* which has relatively large and broadly oblong-ovate, slightly emarginate cotyledons. They are finely pubescent, as are the first pair of coarsely serrated leaves.

***Enkianthus japonicus*, Hook.**

*Hypocotyl* erect, terete, pale green, ultimately glabrous, 8.5 mm. above the soil.

*Cotyledons* oblong-ovate, obtuse, minutely mucronate, alternately penninerved, shallowly crenate, glabrous, shining on both surfaces, bright green above, paler beneath; lamina 8.5 mm. long, 5 mm. wide; petiole flattened above, 1 mm. long.

*Stem* woody, erect, terete, with short decurrent wings from the base and under side of the petioles, pubescent; 1st and 2nd internodes undeveloped; 3rd .5 mm.; 4th 2.5 mm.; 5th 3 mm.; 6th 2.25 mm.; 7th 3 mm.; 8th 1.5 mm.; 9th 1.75 mm.; 10th 1 mm.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, ciliate-serrulate, pubescent above, hairs with short fleshy bases and hooked tips, ultimately glabrous or pubescent on the midrib, paler beneath and pubescent on the principal nerves only, and slightly woolly near the base, alternately penninerved with ascending subincurved nerves; petioles deeply channelled above, subcarinate, pubescent with hairs on the margins and carina like those of the lamina.

Nos. 1-4. Elliptic, acute, serrulate or ciliate-serrulate.

Nos. 5-19. Lanceolate-elliptic, acute, ciliate-serrulate.

Ultimate leaves obovate, apiculate, tapering much to the base, ciliate-serrulate with the hairs hooked forwards as in the cotyledons.



***Erica Tetralix*, L.**

*Hypocotyl* erect, terete, filiform, glabrous, reddish, 8 mm. long.

*Cotyledons* minute, oval, obtuse, glabrous; lamina 1.25 mm. long, 1 mm. wide; petiole .5 mm. long.

*Stem* erect, filiform, ultimately woody, finely pubescent; 1st internode undeveloped; 2nd 3.5 mm. long; 3rd 4.5 mm.; 4th 4 mm.; 5th 3 mm.; 6th 3 mm. The plant was raised in heat; probably the internodes would be much shorter if raised in the open air.

*Leaves* entire, verticillate, shortly petiolate, glabrous in the seedling stage and frequently aristate, ciliate on the lateral nerves in the adult plant, not on the revolute margins, flat in the seedling stage and strongly revolute at the margins in the adult plant, deep green above, glaucous beneath, convex above in the adult, concave beneath; petioles about 1 mm. long, channelled above, ciliate at the margins.

First pair of leaves opposite, obtuse.

Second to fifth nodes with the leaves verticillate in threes, and ovate, subacute.

Then in the seedling noted, five scattered, ovate, aristate leaves occurred; then two nodes each with four verticillate leaves.

Ultimate leaves verticillate with four in a whorl, oblong-ovate, obtuse, trinerved, ciliate on the lateral nerves and strongly revolute at the edges.



FIG. 494.—*Rhododendron arboreum*.  
Nat. size.

***Rhododendron arboreum*,  
Sm. (fig. 494).**

*Primary root* slender, wiry, with numerous lateral rootlets, flexuose.

*Hypocotyl* short, erect, terete, glabrous, about 8 mm. long.

*Cotyledons* small, oval, obtuse, pubescent above, 8 mm. long including the short petiole, 2 mm. wide.

*Stem* woody, erect, terete, glandular-pubescent, reddish; 1st internode 8·5 mm. long; 2nd 2·5 mm.; 3rd 5 mm.; 4th 3 mm.; 5th 5·5 mm.; 6th 3·25 mm.

*Leaves* alternate, evergreen, pubescent above and on the principal nerves beneath, glandular-ciliate, revolute at the margin in veneration, alternately penninerved; petioles channelled above, reddish and pubescent with rufous hairs.

No. 1. Oval, mucronate; lamina 6·5 mm. long, 4·5 mm. wide.

Nos. 2 and 3. Broadly oval, obtuse, mucronate.

Nos. 4–7. Oblong, obtuse, mucronate.

Ultimate leaves oblong-lanceolate, acute, entire, tapering to both ends, slightly revolute at the margin, and somewhat channelled, thinly scurfy and deep green above, densely felted with white or sometimes rusty scales beneath, with a prominent midrib.

*Clethra arborea*, Ait.

*Hypocotyl* covered with minute hairs, 1·5–2·5 cm. long, light green.

*Cotyledons* broadly oblong-ovate, obtuse, slightly emarginate, entire at first, minutely pubescent above, glabrous beneath, green, pinnatinerved like the leaves; petioles rather short and flat, shallowly channelled on the upper side, minutely pubescent.

*Stem* erect, terete, herbaceous, ultimately woody; 1st internode 4–5 mm. long.

*First leaves* opposite, decussate, oblong, acute, coarsely serrate, pubescent, green, pinnatinerved, with short petioles.

## PLUMBAGINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 623.

*Fruit and Seed*.—The syncarpous ovary is superior, and consists of five carpels cohering to form one cell. The ovule is solitary, anatropous, and suspended from a long slender funicle arising from a basal placenta, so that the micropyle is superior. The fruit is dry and included in the persistent calyx, more rarely elongated and somewhat protruding. It is indehiscent, or in some cases the hardened apex falls away

like an operculum leaving the cavity open, or the pericarp is circumscissile near the base, while the portion that falls away is more or less divided into five valves. The seed fills the cavity of the ovary to which it conforms, and is suspended by a long funicle to which it is sometimes adnate, and its testa is membranous. The endosperm is copious, or scanty and farinaceous, or altogether wanting. Where it is present the embryo is straight, axile, and almost equals it in length; but where there is no endosperm the terete or slightly compressed embryo fills the seed. The cotyledons are linear or oblong and equal to or larger than the terete radicle.

In *Plumbago* the cotyledons are much wider than the radicle, and the endosperm is generally scanty. The seeds of *Ægialitis* are linear, exalbuminous and conform to the fruit. The cotyledons of *Armeria grandiflora* are linear-oblong and surrounded by a small quantity of endosperm. The radicle is very short.

*Seedlings*.—Two moderately distinct types of cotyledons were observed, namely, spathulate and linear; but the two are connected by intermediate forms. The tendency to elongation is due to the form of the seed, and that again conforms to the narrow and elongated character of the fruit. Both fruit and seeds vary in width in different species, and so do the cotyledons both before and after germination.

The cotyledons of *Statice speciosa* (fig. 495) are spathulate, obtuse and entire. The first four leaves are also spathulate, more acute, and much larger, and the ultimate ones hardly differ except in their much greater size. The cotyledons of *S. macrophylla-flabellata* differ in being obtuse and slightly emarginate. The first two leaves are rotund and cuneate at the base, followed by three others which are obovate. Intermediate forms between these and the linear type are furnished by *Armeria chilensis* and *Statice Suworowi* (fig. 496). The cotyledons of the former are linear-spathulate and wider than the first pair of leaves. Those of the latter are smaller and narrower than the first leaf which is spathulate-linear. The second and third leaves are also spathulate and

larger, while succeeding ones are scalloped or repandly pinnatifid. The cotyledons of *Statice leptostachya* are long and narrowly linear, while all the leaves are pinnatisect with linear segments.

*Statice speciosa*, L. (fig. 495).

*Primary root* slender, tapering, with a few lateral rootlets.

*Hypocotyl* usually subterranean, tapering downwards, 4 mm. long.



FIG. 495.  
*Statice speciosa*.  
Nat. size.

*Cotyledons* spatulate, obtuse, glabrous, fleshy, dotted on the upper surface with a white excretion, otherwise deep green, 1.25 cm. long including the petiole, 4 mm. wide about the middle of the lamina.

*Stem* very short.

*Leaves* simple, entire, radical, alternate, exstipulate, sessile, glabrous, opaque, coriaceous, glaucous-green above, and closely dotted with a white excretion, much paler beneath, tapering gradually to the base, forming a broad-winged petiole-like stalk, shallowly grooved above, dilated and sheathing at the base.

No. 1. Spathulate, obtuse, obscurely apiculate.

Nos. 2 and 3. Spathulate, obtuse, apiculate, tapering to a narrow base.

Ultimate leaves obovate-spathulate, cuspidately acute, subcartilaginous at the margin, obscurely alternately penninerved with the nerves ascending, then spreading and lastly somewhat incurved.

*Statice macrophylla*, Brouss., var. *flabellata*.

*Hypocotyl* very short, erect, terete, glabrous, reddish.

*Cotyledons* spatulate, obtuse, minutely emarginate with a distinct midrib, glabrous, light green, 1.7 cm. long.

*Stem* very short, developing slowly, and becoming woody; primary internodes undeveloped.

*Leaves* radical and ultimately cauline, ciliate, otherwise glabrous, aristate at the apex, with a distinct midrib, and indistinctly alternately penninerved, light green; petioles flattened above, dilated and clasping at the base, ciliate at the margin.

Nos. 1 and 2. Rotund, cuneate at the base.

No. 3. Broadly obovate, rounded at the apex, cuneate or tapering at the base.

**Statice Suworowi, Regel (fig. 496).**

*Primary root* as in *S. speciosa*; annual.

*Hypocotyl* subterranean, tapering, 3 mm. long.

*Cotyledons* linear-spathulate, obtuse, glabrous, narrowed to a petiole, 7.5 mm. long including the petiole, 1.75 mm. wide near the apex.

*Stem* herbaceous, annual.

*Leaves* as in last species; soft, fleshy in the young state; petioles grooved above, convex on the back, dilated and sheathing at the base.

No. 1. Small, spathulate-linear.

No. 2. Narrowly spathulate, obtuse.

No. 3. Spathulate, subacute.

No. 4. Spathulate, aristate, scalloped at the base with a rounded lobe on each side; lobes always alternate on all the following leaves.

No. 5. Oblong, aristate, constricted below the middle; terminal lobe ovate; lower one subrhomboid, slightly decurrent on the petiole.

Nos. 6–8. Narrowly oblong, scalloped with rounded lateral lobes, and an ovate aristate terminal one.

Ultimate leaves oblong or obovate-oblong, obtuse, aristate at the apex, scalloped or subpinnatifid, with alternate or sub-opposite, obtuse lobes, obscurely and alternately penninerved, with ascending nerves running into the lobes.

**Statice leptostachya, Boiss.**

*Primary root* slender, tapering downwards, with numerous slender lateral rootlets, annual.

*Hypocotyl* not developed or tapering into, and indistinguishable from the root.

*Cotyledons* linear, obtuse, tapering into a long petiole-like base, slightly channelled above, and much dilated at the extreme base, glabrous but with small depressions on the upper surface, and prominences towards the top, green with a reddish base, 1.4–1.6 cm. long, .5–1 mm. wide.

*Stem* extremely short, herbaceous, annual, and throwing up a scape when about to flower. Internodes undeveloped.

*Leaves* radical, glabrous, but covered with minute, scale-like



FIG. 496.—*Statice Suworowi*.  
Nat. size.

dots, obscurely alternately penninerved, pinnatisect with linear, obtuse, entire segments, revolute at the margins so as to make them convex above, and concave or furrowed beneath; petioles semiterete, glabrous, channelled above with rather acute edges, reddish, dilated and clasping at the base.

No. 1. Linear, pinnatifid or -sect, with a few subulate, obtuse, alternate segments; middle ones longest; terminal one triangular-hastate.

Nos. 2-6. Gradually longer and larger, pinnatisect with alternate, obtuse, subulate and linear segments; terminal lobe becoming less and less conspicuous until it is almost absent, the leaf ending in two lateral segments.

***Armeria grandiflora*, Hort.**

*Fruit* a one-celled utricle, one-seeded.

*Seed* narrow, oblong 1-1.25 mm. long, testa thin, membranous, smooth; hilum inconspicuous.

*Endosperm* scanty, surrounding the embryo, white, farinaceous.

*Embryo* straight, whitish-green; cotyledons linear-oblong, obtuse, entire, plano-convex, lying face to face; radicle short, subacute, terete, considerably shorter than the cotyledons.

***Armeria chilensis*, Boiss.**

*Primary root* long, tapering downwards, fibrous.

*Hypocotyl* extremely short and subterranean, or indistinguishable from the base of the root.

*Cotyledons* linear-spathulate, obtuse, entire, tapering to the base and connate, forming a sheath to the plumule, the midrib indistinct, glabrous, bright green, 1.1-1.6 cm. long.

*Stem* with undeveloped internodes.

*Leaves* simple, entire, radical, alternate, tufted, very thinly pubescent in the young state or almost glabrous, sessile or at least the primary ones.

Nos. 1 and 2. Linear, obtuse, showing a midrib only which is shallowly furrowed on the upper surface and more conspicuously so beneath, narrower than the cotyledons.

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## PRIMULACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 628.

*Fruit and Seed.*—The ovary is superior or rarely more or less inferior as in *Samolus*; and consists of five or six carpels cohering so as to form one cell. The ovules are numerous or few, but never less than two and inserted upon a free-central, sessile, or stalked placenta, on the surface of which they are placed or are immersed in it, semianatropous with a ventral attachment or rarely anatropous as in *Hottonia*. The fruit is a capsule dehiscent by two to six valves (very frequently five) with the valves entire or bifid, very rarely is it circumscissile as in *Anagallis*, or indehiscent as in a few species of *Lysimachia*. The seeds are few or numerous, arranged on the surface of the central placenta or immersed in it, peltate or attached by the ventral face and very frequently depressed and variously angled. The membranous testa is smooth, furrowed or granular, sometimes winged and adnate to a copious fleshy endosperm. The embryo is small, terete or cylindrical, and lies embedded in the endosperm parallel or crosswise to the hilum, rarely pointing to it and often uncertain in its direction. The cotyledons are blunt and very small, but become foliaceous during germination.

*Seedlings.*—In the Primulaceæ, three distinct types of cotyledons were observed. The leading and most characteristic type is ovate; a few are spatulate or show some modification of that form; and in *Cyclamen* we have a reniform, foliaceous and solitary cotyledon. One of the most highly developed forms is that of *Lysimachia ciliata* (fig. 501), the cotyledons of which are ovate, acute and greatly resemble the first pair of leaves although smaller and with a less evident venation. Those of *Anagallis arvensis* are lanceolate-ovate, while the leaves from the first are broadly ovate, opposite, decussate, glabrous, but marked with black spots beneath. A considerable number of the species of *Primula* have ovate cotyledons, including *P. veris* and *P. denticulata*. The first leaf of the former is cordate, entire or slightly toothed, while

that of the latter is widely and shallowly crenate. *P. denticulata* is also notable for the shortness of its hypocotyl and the length of the petioles of the cotyledons which compensate for this deficiency. The cotyledons of *P. elatior* (fig. 497) differ in being ovate-oblong and trinerved. The first leaf is reniform, and the second is rotund-cordate; both are dentate. The cotyledons of *Androsace rotundifolia* on the other hand are broadly ovate and short. The first leaf is somewhat triangular and entire or tridentate; and succeeding ones vary between reniform and orbicular, palmately nerved and lobed. A modification of the ovate type occurs in *P. vulgaris* and *P. sinensis*. Those of the former (fig. 498) are ovate, emarginate, three- or faintly five-nerved, and finely glandular-pubescent. The first two leaves are ovate. This species is remarkable for the behaviour of the radicle and hypocotyl under different conditions and in different soils. In sand the radicle strikes down vertically, but in soil of a stiffer nature it generally grows along the surface for some little way before striking downwards, and the hypocotyl generally bends in the same way and throws out lateral rootlets, abundantly provided with root-hairs. The radicle soon ceases to elongate and, gradually dying away as a procumbent stem or rhizome is formed, gives rise to the popularly so-called præmorse root. The cotyledons of *P. sinensis* (fig. 499) are normally broadly ovate and emarginate, but they frequently behave in an irregular manner, one of them often being bifid or bipartite and sometimes divided to the base of the petiole making apparently three cotyledons. In those that are bifid the midrib becomes forked at some distance below the sinus. Both cotyledons are bifid in some cases; and they are coarsely hairy and glandular. The primary leaves are cordate and more or less lobed and toothed. A second type is met with in *Soldanella*. The cotyledons are oval and obtuse at either end. The first three leaves are reniform and entire. Spathulate cotyledons are met with in *Androsace nana*. The primary leaves are narrower, linear-lanceolate, entire and arranged in a dense rosette. Those of *Asterolinum splendidum* are similar in shape but opposite and decussate, with the internodes more elongated. The cotyledons



are linear-spathulate or oblong. A fourth type is presented by *Cyclamen*. This genus has only one cotyledon which soon becomes foliaceous and of large size resembling a true leaf. The cotyledon of *Cyclamen persicum* is cordate and more or less crenate, greatly resembling the first true leaf. In a batch of seedlings, individuals may frequently be found having the cotyledons consisting of two reniform, sessile, or stalked pieces resembling a compound leaf with a pair of leaflets. The apparently compound character is perhaps due to the union of the petioles of the cotyledon and the first true leaf, as occasionally happens in the case of the peduncles and the leaves.

***Primula elatior*, Jacq. (fig. 497).**

*Primary root* normal, ultimately giving way to the strong adventitious roots developed below the cotyledons and the rosette of leaves.

*Hypocotyl* slender, about 6 mm. long, colourless.

*Stem* a short, persistent, fleshy, or almost woody rhizome with undeveloped or slightly developed internodes.

*Cotyledons* ovate-oblong, obtuse, somewhat succulent, pale green, glabrous; lamina 5-7 mm. long, 3-4 mm. wide; petiole slightly channelled above, slightly pubescent, 3.5 mm. long.

*Leaves* simple, radical, alternate, exstipulate, petiolate, rugose, glabrous above, hairy beneath; petioles (in young plant) deeply channelled above, not winged, hairy, almost villous on the under side.

No. 1. Reniform, repand-dentate, with short, broad, mucronate teeth, and a diverging basal sinus, reticulate.

No. 2. Rotund-cordate, dentate-serrate, convex above with recurved mucronate teeth.

Ultimate leaves oblong-ovate, abruptly decurrent on the petiole, shallowly and subrepandly dentate, alternately penninerved, reticulate, rugose.



FIG. 497.  
*Primula elatior*.  
Nat. size.

***Primula denticulata*, Sm.**

*Hypocotyl* subterranean or short.

*Cotyledons* apparently springing straight from the root, ovate,

obtuse, with ascending petioles, from 8–4 mm. long, finely ciliated ; midrib indistinct.

*Stem* apparently none.

*Leaves* radical, petiolate ; the first one is ovate, obtuse, cordate at the base, crenate, ciliate and covered with small hairs, light green ; midrib with numerous branched lateral veinlets.

***Primula vulgaris*, Huds. (fig. 498).**

*Primary root* behaving differently in different soils. In silver sand a number of specimens examined penetrated the soil per-

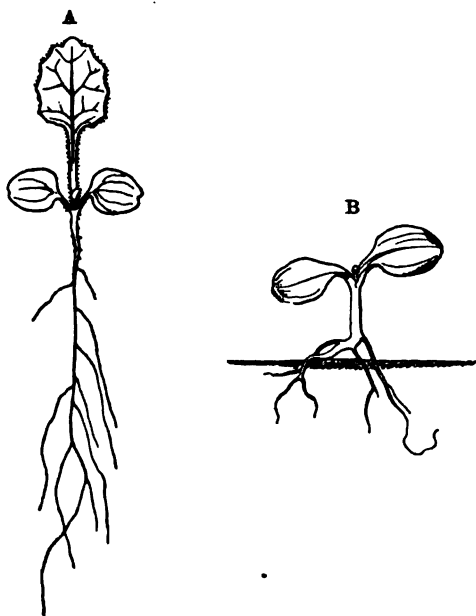


FIG. 498.—*Primula vulgaris*. A, grown in sand. Nat. size.  
B, grown in loam and sand,  $\times 2$ .

pendicularly. In loam with a mixture of sand the radicle or base of the hypocotyl bends or becomes procumbent in many instances before penetrating the soil. In some cases it soon ceases to elongate and throws out strong lateral rootlets furnished with an abundance of root-hairs.

*Hypocotyl* erect (at least primarily), terete, densely clothed with a glandular pubescence, pale green, throwing out strong adventitious roots at its base with an abundance of root-hairs.

*Cotyledons* ovate, obtuse, emarginate, finely glandular-pubescent all over, petiolate, alternately incurvinerved, with two strong nerves from near the base on either side the prominent midrib, the two upper are stronger, and incurving unite with the midrib in the apical sinus; lamina 5-7 mm. long, 5-6 mm. wide; petiole channelled above, glandular-pubescent, 2.5-3.5 mm. long.

*Stem* always short, with undeveloped internodes, fleshy, ultimately forming a persistent rhizome.

*Leaves* radical, alternately penninerved, reticulate, rugose, with more or less branched and flexuose nerves running into the marginal teeth, finely glandular-pubescent in the seedling stage, and more or less coarsely hairy in the adult plant or subvillous beneath, light green; petioles semiterete, dilated towards the base, deeply channelled above, coarsely hairy and glandular-pubescent, or subvillous in the adult plant.

No. 1. Ovate, obtuse, suddenly tapering at the base into the petiole, irregularly dentate, with the teeth tipped with a gland-like mucro, even or slightly rugose.

No. 2. Similar but more rugose.

*Primula sinensis*, Lindl. (fig. 499).

*Primary root* tapering, flexuose, with fibrous lateral rootlets, somewhat bent or curved at its junction with the hypocotyl, from which strong adventitious roots are generally developed at an early age—all abundantly provided with root-hairs.

*Hypocotyl* as in *P. vulgaris*.

*Cotyledons* broadly ovate, obtuse, emarginate, mucronate in the notch, subcordate and trinerved at the base, the lateral nerves branching so as to form five; alternately nerved and reticulate upwards (nervation indiscernible except by transmitted light), glandular-pubescent on all parts, but especially on the upper surface; lamina 5.5-8 mm. long, or more when fully developed, 5-7 mm. wide; petiole 1.5-2.25 mm. long, semiterete, channelled above, glandular-pubescent, pale green.

When the cotyledons divest themselves early of the testa and remains of the endosperm it is seen that there is no emargination, and the mucro is the most prominent point of the cotyledon. This mucro consists of clear, colourless tissue embedded in the tissue of the cotyledon with its lower and cuneate end in direct communication with the midrib, and that again with the vascular bundle running down the hypocotyl and entering the root. The midrib tipped with the mucro ceases to develop after a time while the surrounding tissue grows, resulting in emargination. Variations from the above

type occur irregularly in different individuals. There are a few large openings in the mucro, confined to the very tip.

The midrib in some cases forks a little way above the base of the cotyledon, diverges and runs to the margin where each fork ends in a mucro. Fission occurs between these two mucronate tips in one, or occasionally both cotyledons while yet in the seed. After germination the mucronate tip ceases after a time to elongate, and growth of the surrounding tissue causes the emargination of both halves of the cotyledon. In this case there is a median fissure, and two shallower lateral ones.

The forking of the midrib in other seedlings may arise below the base of the lamina when the cotyledon becomes more or less deeply bifid. Again this forking may be carried down so far that one (seldom or never both) cotyledon is divided nearly to the base of the petiole, when there appear to be three distinct cotyledons with laminae and petioles.

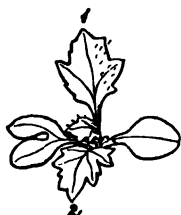


FIG. 499.  
*Primula sinensis*.  
With bifid cotyledon.  
Nat. size.

When the seed is carried up on the tips of the cotyledons, the latter as they develop make a great but unsuccessful effort to divest themselves of the now dried-up testa and remains of the endosperm. The sides of the laminae become revolute longitudinally at an early stage so as to present their outer surface to the light. At length only the tip of the cotyledons is held fast; and the petioles twist so as to bring the upper surface of the laminae outwards to the light.

In deeply bifid cotyledons the division of the central vascular bundle takes place low down in the petiole; a branch runs down the centre of each half to the apex, where it is tipped with a mucro.

*Stem* short, stout, fleshy with scarcely developed internodes.

*Leaves* coarsely hairy on both surfaces and dotted with sessile glands, dull green above, paler beneath, sometimes suffused or coloured brownish-red; petioles semiterete, channelled above, coarsely hairy and glandular, dilated and sheathing at the base.

No. 1. Cordate, obtuse, five-nerved at the base, and alternately penninerved upwards, becoming doubly dentate-serrate.

No. 2. Cordate, subacute, lobulate with the lobes somewhat dentate.

No. 8 is similar, or more decidedly lobulate.

*Androsace rotundifolia*, *Hardw.* (fig. 500).

*Primary root* quite normal.

*Hypocotyl* very short, tapering downwards, slightly pubescent, very pale and marked with red dots; 1.5–2 mm. long.

*Cotyledons* short, ovate, obtuse, entire, thinly glandular-pubescent, tipped with a minute tooth, without discernible venation when fresh; lamina 2-8 mm. long, 1.75-2.25 mm. wide; petiole flattened or slightly grooved above, thinly glandular-pubescent, 1-1.25 mm. long.

*Stem* herbaceous, developed when about to flower; primary internodes undeveloped.

*Leaves* simple, radical, alternate, palmately three- to five-nerved, and lobed or toothed, glandular-pubescent (with the hairs tipped by a red gland), dull opaque green above, suffused and mottled with red beneath; petioles semiterete, channelled above, densely glandular-pubescent with red glands, very pale green, mottled and striated with red, dilated and clasping at the base.

No. 1 (and in small seedlings sometimes No. 2). Cordate-triangular, obtuse, entire or with a minute glandular tooth on each side, tipped with an obtuse glandular tooth, obscurely trinerved.

No. 2. Similar or larger and reniform, five-nerved and five-toothed.

No. 3. Rotund-reniform, five-nerved, obtusely five-toothed.

No. 4. Rotund-cordate, five- to seven-nerved, and toothed or sub-lobulate.

*Androsace nana*, *Hornem.*

*Hypocotyl* erect, terete, glabrous, 8-12 mm. long, pale green or colourless.

*Cotyledons* slightly obovate or spatulate, 6-7 mm. long including the short petiole, glabrous, dark green; venation very indistinct.

*Stem* as in last species.

*First leaves* radical, arranged in a rosette, entire, linear-lanceo-



FIG. 500.—*Androsace rotundifolia*,  $\times 8$ .

late, acute, hispid (hairs very short and stiff), tapering to the base, almost petiolate, with a midrib, but no lateral nerves apparent.

**Soldanella sp.**

*Primary root* long, slender, tapering somewhat abruptly below the cotyledons, with numerous fibrous rootlets.

*Hypocotyl* not appearing above the soil, scarcely developed.

*Cotyledons* minute, ovate, obtuse, entire, petiolate, glabrous, green, without any distinct venation; the surface is covered with numerous minute pit-like depressions.

*First leaves* simple, entire, radical, alternate, oblate or almost reniform, obtuse, slightly and shallowly cordate at the base, exstipulate, glabrous, dark green, trinerved; petioles long, shallowly furrowed or channelled on the upper side.

**Cyclamen persicum, Mill.**

*Primary root* simple, flexuose, with numerous root-hairs, and soon assisted by numerous adventitious rootlets as strong as itself, springing from the base of the hypocotyl.

*Hypocotyl* globose, fleshy, almost colourless at first, becoming afterwards pinkish, then darker, ultimately brown, covered at an early stage with minute brown hairs, forming the persistent rootstock of the plant, and gradually attaining a considerable size.

*Cotyledon* one, cordate, obtuse, gradually enlarging and performing the functions of a leaf which it resembles in all respects, alternately and incurvedly penninerved, each lateral nerve uniting with the one above it, and giving off branches towards the margin which form a series of reticulations as the lamina enlarges, crenate, frequently bearing smaller teeth between, and sometimes glandular papillæ, glabrous above, deep opaque green, or finally with pale green or greyish markings, minutely pubescent beneath, and generally deep red; petiole long, terete at the base, shallowly channelled upwards, minutely pubescent, pale green or more often stained with red.

Exceptions occur where the cotyledon assumes the appearance of a compound leaf. Occasionally there are two reniform laminæ on a common petiole united to the very apex, while at other times the petiole is separated into two for some considerable way down, each bearing a reniform, crenate or angled lamina. Sometimes three leaves are thus united with the cotyledon instead of one, and when the lower pair is small they appear like stipular organs at the top of the petiole. The venation of each lamina is similar to that of an ordinary cotyledon. In a pot of eighteen seedlings, eight showed

some such monstrosity. The petioles of the adult plant are occasionally adnate to the peduncles, which thus assume a caulescent appearance.

*Leaves* simple, radical, alternate, exstipulate, petiolate, radiately five-nerved in seedlings, ultimately seven- to nine-nerved, irregularly crenate at the margin, glabrous above and deep green marked with grey, paler beneath, or more or less suffused with red, minutely and papillosely pubescent; petiole subterete, shallowly grooved towards the base, papillosely and minutely pubescent.

No. 1. Reniform, five-nerved with the nerves radiating and incurved towards their tips where they branch and anastomose.

Ultimate leaves broadly cordate, obtuse, seven- to nine-nerved, with the midrib and some of the stronger nerves more or less alternately penninerved; all the lateral nerves incurve towards their tips, and give off strong branches on their posterior side towards the margin, forming large reticulations. Small branches are given off into the crenatures.

Gressner (Bot. Zeit. 1874, p. 837) says there is a slight eminence which represents the second cotyledon, and which subsequently develops into a leaf, so that *Cyclamen* has two cotyledons which resemble leaves. Richard, Treviranus, and Gaertner (who first wrote about it) say only one.

The germination of *Cyclamen* has been described by Gaertner,<sup>1</sup> Richard,<sup>2</sup> Mirbel,<sup>3</sup> Treviranus,<sup>4</sup> Gressner,<sup>5</sup> and Darwin.

The cotyledons first appear as two small eminences, one of which makes no further growth, while the other develops into a green cotyledon resembling the true leaf of the plant.

Dr. M. T. Masters (Gardener's Chron. 1887, p. 596) agrees with Gaertner and Treviranus, as against Mirbel, that there is only one cotyledon, but the first two, three, or even four leaves sometimes have their petioles connate.

*Lysimachia ciliata*, L. (fig. 501).

*Primary root* tapering downwards and flexuose, giving off a few lateral rootlets, but soon superseded by strong adventitious roots from the hypocotyl.

*Hypocotyl* short, erect, thickened upwards, glabrous, closely and minutely dotted with red, 4-5 mm. long.

<sup>1</sup> *Carpologia*, vol. iii. p. 25.

<sup>2</sup> *Analyse du Fruit*, Paris, 1808, p. 83. English translation by Lindley, *Fruits and Seeds*, London, 1819, p. 71.

<sup>3</sup> *Ann. du Muséum*, vol. xvi., 1811, p. 454, tab. xvi.

<sup>4</sup> *Symb. Phyt.* Fasc. i., 1831, p. 86, and tab. iii., figs. 66-71.

<sup>5</sup> *Bot. Zeit.* 1874, pp. 801, 17, 81.

*Cotyledons* ovate, acute, entire, glabrous, with a distinct midrib, but no other venation discernible, deep green above, paler beneath; lamina 4–7 mm. long, 3–6 mm. wide; petiole channelled above, convex on the back, 2·5–6 mm. long, slightly connate at the base, glabrous, dotted with red.



FIG. 501.—*Lyrimachia ciliata*.  
Nat. size.

*Stem* herbaceous, throwing up annually leafy, flowering stems from a persistent rootstock, quadrangular, densely covered with a glandular pubescence; 1st internode 5–1·25 mm. long; 2nd 1–3·5 mm.; 3rd 1–10 mm.

The internodes are more developed when the seedlings are crowded than when they have plenty of space.

*Leaves* simple, entire, cauline, opposite, alternately incurvined, obscurely reticulate, minutely glandular and deep green on the upper surface, paler beneath; petioles semiterete, channelled above, more or less thinly ciliate along the edges in the seedling stage, but more decidedly so in the adult plant with coarse hairs or fringes, slightly connate at the very base.

First pair ovate, obtuse, similar to the cotyledons, but slightly larger.

Second to fourth pairs ovate, gradually larger and more acute.

#### *Asterolinum splendidum*, Auct.

*Hypocotyl* erect, terete, glabrous, colourless below the soil, green above it, 1–1·5 cm. long.

*Cotyledons* linear-oblong, obtuse, glabrous, tapering at the base but scarcely petiolate, entire, 8–10 mm. long, 1–2 mm. wide, bright green, lighter beneath, buds which develop into branches are formed in their axils.

*Stem* herbaceous, erect, terete, glabrous, pale green; 1st internode 8–3·5 mm. long; 2nd only from 1·5–2 mm.

*Primary leaves* cauline, simple, opposite, decussate, sessile, entire, linear-lanceolate, acute, glabrous, light green.



**Anagallis arvensis, L.**

*Hypocotyl* erect, terete, glabrous, 5–8 mm. long, almost colourless, with occasionally a slight reddish tinge.

*Cotyledons* ovate-lanceolate, obtuse, entire, glabrous, green with brown spots beneath, indistinctly one-nerved; petioles short, very slightly flattened above.

*Stem* erect, or procumbent in rich soils, quadrangular, herbaceous; 1st internode 5–6 mm. long; 2nd shorter.

*First leaves* simple, entire, cauline, opposite, decussate, broadly ovate, obtuse or subacute, glabrous, green with dark spots beneath, trinerved at the base.

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**MYRSINÆ.**

Benth. et Hook. *Gen. Pl.* ii. 639.

*Fruit and Seed.*—The ovoid or globose ovary is superior, or inferior in *Mæsa*, one-celled with few or numerous ovules inserted on a free-central globose placenta or deeply immersed in it, amphitropous or anatropous. The fruit is globular, drupaceous or baccate, with a pulpy exocarp and a crustaceous endocarp, one- or few- very rarely many-seeded. The seed is nearly always solitary and globose, conforming to the interior of the cavity, often umbilicate at the base with a shallow or deep cavity owing to a thickening or swelling of the placenta the sides of which are prolonged into a cup-shaped membrane surrounding the base of the seed. Much more rarely the seeds are numerous and small or relatively large, tumid, bluntly angled and obliquely affixed to the placenta. The testa is membranous and closely adheres to the copious, fleshy or horny, smooth or ruminated endosperm. The embryo when normal is transverse to the placenta in all cases where the seed is solitary; but where the seeds are more numerous in a fruit, the embryo is more or less axile or excentric, and cylindrical, curved or arcuate. The cotyledons are small and of the same width as the radicle, which is elongated and terete; in some cases they are foliaceous.

The fruits observed all belong to the genus *Ardisia*, and are globose, drupaceous, and one-seeded. The seed is

shallowly indented at the base, while on the other hand there is a slight swelling at the micropyle caused by the radicle being closely pressed against it. The embryo when normal is transverse to and parallel with the placenta, but there are exceptions when more than one embryo occurs in a seed.

The fruit of *Ardisia polycephala* is depresso-globose, and considerably flattened on the top. The embryo is terete and thickened or clubbed at the tip of the radicle, with the back of the cotyledons to the placenta. The fruit of *A. japonica* (fig. 504) is perfectly globular with exception of the basal indentation. The seed presents the remarkable peculiarity of often containing several embryos, as many as six being sometimes present. The radicle in such a case points in various ways, and in germination each embryo makes its exit at different places. Even although the embryo is solitary in a seed of *A. crenulata*, it is nearly always excentric and ascending. The cotyledons of this species never leave the seed, but during germination they attain a considerable size, and become slightly convolute with the edge of one within that of the other.

*Seedlings.*—There is considerable variation amongst the seedlings of this Order, and of the four genera and eight species observed hardly any two are exactly alike in form as far as the cotyledons are concerned. Those of *Mæsa argentea* are small, oval, and entire. The first leaf is ovate and serrate, the size rapidly increasing in succeeding ones. The cotyledons of *Jacquinia ruscifolia* are oblong-ovate, coriaceous, and very persistent. The first pair of leaves are opposite, elliptic, and larger than the cotyledons. The second pair are also opposite, smaller, and sometimes at least very unequal in size. After this the leaves are lanceolate-elliptic, and whorled.

A very remarkable case occurs in *Embelia Ribes* (fig. 502) the cotyledons of which are ovate, acute, glandular-ciliate and finely serrate along the whole margin in the young state, but ultimately on the upper half only, owing apparently to intercalary growth at the base. The venation of the full-grown cotyledons would seem to indicate the same fact, for the trinerved condition of the upper part is evidently

that most commonly characteristic of cotyledons, while the venation of the lower half corresponds to that of the leaves. The first leaf is similar in shape to the cotyledons but smaller. Succeeding ones are larger and gradually pass through ovate and elliptic to lanceolate forms. The plant itself is shrubby, erect at first, but ultimately climbing.

The cotyledons of *Embelia viridiflora* are large, elliptic, somewhat undulated, entire, and persistent. The growth of the stem is very much interrupted, and at the lower part of each growth some of the leaves are small and scale-like, followed by a few that are similar in shape to the cotyledons but larger.

The four species of *Ardisia* examined have cotyledons widely different in form, and differ more or less widely in their mode of germination. The cotyledons of *A. polycephala* (fig. 506) are elliptic, emarginate, foliaceous, and persistent, with an incurved penninerved venation like that of the leaves, the first two of which are similar, but larger and entire. Succeeding ones rapidly increase in size, but especially in length.

In *A. mamillata* (fig. 505) the hypocotyl is short but very stout and fleshy. The cotyledons are aerial but small, oblate, bifid and hairy. Those of *A. crenulata* (fig. 503) are small, spatulate, and petiolate, but never leave the seed. The latter if fairly well covered with soil remains underground, when the petioles of the cotyledons attain a few millimeters in length; but if the fruit with its seed is uncovered the cotyledons are almost sessile, and the seed gets carried up by the elongating hypocotyl. This is more decidedly the case in *A. japonica* (fig. 504), the hypocotyl of which varies from 1.3–3 cm. in length. The cotyledons are small, ovate and never leave the seed, which therefore gets carried up with the growth of the seedling. The petioles of the cotyledons are both directed to one side of the axis, flattened, pubescent, and become undulated as they lose substance and fade. The first three leaves vary from oval to rotund and ovate, and are serrate like the adult leaf which is evergreen. Several seedlings often proceed from the same seed, as mentioned above.

***Musa argentea*, Wall.**

*Hypocotyl* short, erect, terete, glabrous, .75–1 mm. long greenish.

*Cotyledons* small, ovate or oval, obtuse, entire, petiolate, glabrous, green, one-nerved; petioles short, channelled above.

*Stem* erect, terete, herbaceous, ultimately woody, stout, pubescent; 1st internode about 1 mm. long; 2nd 1.5–2 mm.; 3rd, 4th, and 5th rather longer.

*First leaves* simple, cauline, alternate, exstipulate, petiolate, oblong, acuminate, coarsely serrate, covered when young with a minute pubescence, afterwards apparently glabrous, green, distinctly pinnatinerved; petioles stout, deeply channelled on the upper face.

***Embelia Ribes*, Burm. (fig. 502).**

*Primary root* normal, but soon superseded by strong adventitious roots from its base, or from the base of the hypocotyl.

*Hypocotyl* erect, terete, densely and finely glandular-pubescent, pale green spotted or striped with brown, 2–2.5 cm. long.

*Cotyledons* ovate, obtuse or subacute, indistinctly alternately



FIG. 502.—*Embelia Ribes*. Half nat. size.

incurvinerved and reticulate, distantly serrate in the upper half, tapering into a petiole, bright green and shining above, much paler beneath, and dotted with sunken black glands, thinly glandular-pubescent at the margins when young; lamina 1.4–1.5 cm. long, 9.5–11.5 mm. wide; petioles semiterete, slightly furrowed above, finely glandular-pubescent, forming a slight rim around the stem at their base, 2.5–3.5 mm. long.

*Stem* erect in the young state, terete, finely glandular-pubescent, subflexuose, pale green minutely dotted with brown, ultimately woody and scandent; 1st internode 2.25–5 mm. long; 2nd 3.5–5 mm.; 3rd 2.5–4 mm.

*Leaves* alternate, alternately incurvinerved, and indistinctly reticulate, rather thick, shining on both surfaces, bright green above, paler beneath and glandular, thinly glandular-pubescent on

both surfaces; petioles semiterete, channelled above, thickly glandular-pubescent, tapering downwards and articulated with the stem.

No. 1. Broadly ovate or short elliptic, acute, serrate except towards the base.

No. 2. Elliptic, otherwise like the first.

Nos. 3 and 4. Lanceolate-elliptic, acute, tapering and entire at the base.

Nos. 5-7. Lanceolate, acuminate, otherwise similar to Nos. 3 and 4.

*Embelia viridiflora*, Scheff.

*Hypocotyl* woody, 3-5 cm. long, about 3 mm. thick, terete, glabrous, lenticelled, greyish-brown.

*Cotyledons* shortly petioled, 2.5-3.5 cm. long, nearly 2 cm. wide, elliptic-lanceolate, subacute at the base, penninerved, with sunk midrib and an entire undulate margin, quite glabrous, somewhat leathery, shining dark green above, very slightly paler beneath, very persistent.

*Stem* like the hypocotyl, with internodes of very unequal length; the younger part succulent and bright green.

*Leaves* entire, glabrous, coriaceous, intense green on both sides, beset with black translucent glands of two forms, round and oblong or linear; petioles short, flat or channelled above, somewhat margined in the upper part by the decurrent lamina.

The first leaf is very little above the cotyledons, and exactly like them except for the translucent glands.

Succeeding ones are only larger and more distant from each other—most of the glands are round, but some are oblong or linear.

This interesting plant presents interrupted growth within a small space of time similar to that of many fruit trees. In the present case four distinct growths occurred in the primary axis not more than 10 cm. long, namely, one growth ending in the seed leaves 4.8 cm. long; a second consisting of the first four internodes 8 mm. long; the next about 2.8 cm.; and the last only 1.5 cm.

Furthermore the shoots of the stem bear one, two or more alternate small leaves or scales on their lower part, and generally only two well-formed leaves at the top.

*Ardisia crenulata*, Vent.

*Fruit* a drupe, globose, indented or umbilicate at the base, minutely so at the apex, glabrous, deep bright red when mature;

epicarp thin; mesocarp pulpy, pale pink or almost colourless; endocarp crustaceous, marked longitudinally from base to apex with strong, simple or somewhat forking nerves; placenta prominent, causing a slight indentation in the base of the seed, and thinned away towards the sides, forming a cup round the base of the seed.

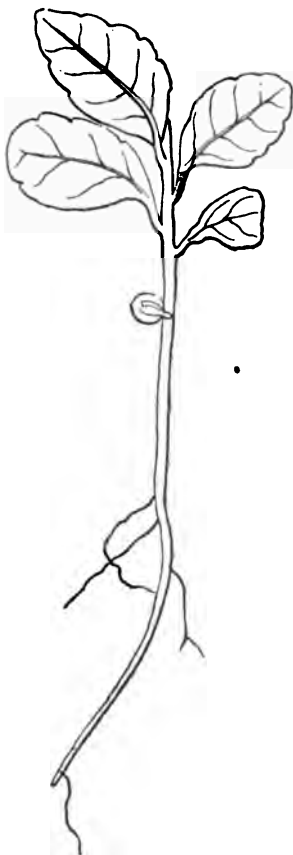


FIG. 508.—*Ardisia crenulata*.  
Nat. size.

*Seed* solitary, globose, slightly indented at the base, conforming to the cavity of the ovary; testa thin, pale brown, membranous.

*Endosperm* fleshy, subtransparent, firm, but when dry horny, constituting the greater bulk of the seed.

*Embryo* straight, transverse to the seed, or more often ascending, more than half the width of the seed, but proportionately much shorter than that of *A. japonica* or *A. polyccephala*, 2.75–8.25 mm. long; cotyledons minute, ovate, obtuse, entire, colourless, lying with their edges perpendicular to the hilum; radicle cylindrical, stout, obtuse, abutting against the testa and causing a slight elevation, pale greenish, several times longer than the cotyledons, horizontal or more often ascending.

#### Seedling (fig. 508).

*Primary root* long, fleshy, gradually tapering, giving off a few scattered lateral rootlets.

*Hypocotyl* terete, fleshy, stout, pale or dirty white beneath the soil, and pale green dotted with red above it, minutely pubescent, about 2 cm. long, 1.5–2 mm. thick.

*Cotyledons* spatulate, remaining in the testa until the endosperm is exhausted, and carrying up the testa with them, ultimately perishing and falling away.

*Stem* erect, terete, fleshy and soft, ultimately frutescent, minutely pubescent, pale green dotted with red, subverrucose; 1st internode 6.5 mm. long; 2nd 2 mm.; 3rd 1.5 mm.; 4th 8.5 mm.

*Leaves* alternate, evergreen, crenate, obtuse or emarginate, deep green above, paler beneath, glabrous, with a row of submarginal red glands evident on both surfaces, sometimes also developing scattered glands all over the upper surface; petioles very short, flattened above or subchannelled.

No. 1. Small, spatulate or obovate, truncate.

Nos. 2 and 3. Oval, obtuse.

No. 4. Elliptic, narrowed somewhat to both ends, minutely emarginate.

*Ardisia japonica*, Blum. (fig. 504).

*Fruit* a globose drupe, scarlet, glabrous; epicarp thin; mesocarp pulpy; endocarp pale brown, crustaceous, marked longitudinally with strong nerves; placenta prominent, thickened, causing an indentation at the base of the seed, thinning away towards the sides and forming a cup surrounding the base of the seed.

*Seed* as in *A. crenulata*.

*Endosperm* copious, constituting nearly the whole bulk of the seed, sub-transparent.

*Embryo* similar to that of the last species, but reaching almost across the seed, the cotyledons, which are equal in width to the radicle at their base and tapering towards the tip, lying just within the endosperm on one side of the seed, or directed towards the base in cases where the radicle ascends; radicle many times longer than the cotyledons.

When the embryo is solitary it is transverse to the axis, but the number of embryos varies from one to six; when several they assume various directions, ascending, erect or suberect, and nearly or quite perpendicular to the placenta.

### Seedling.

*Hypocotyl* similar to that of *A. crenulata*.

*Cotyledons* small, ovate, with long petioles, remaining in the seed; petioles flattened above and channelled, glandular-pubescent or ciliate.

*Stem* erect, terete, densely glandular-pubescent and red, at least when young, ultimately woody; first internode undeveloped; 2nd and 3rd each about .5 mm. long.

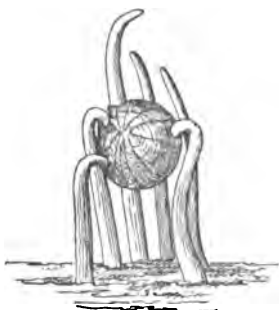


FIG. 504.—*Ardisia japonica*.  
Germinating seed, showing  
six embryos,  $\times 2$ .

*Leaves* alternately penninerved and reticulate, minutely glandular-pubescent on both surfaces, and beset with orange-coloured, pellucid glands in the tissue all round the margin of the leaf, deep green above, paler beneath, more or less shining on both surfaces, evergreen; petioles short, semiterete, channelled above, finely glandular-pubescent, reddish.

No. 1. Transversely oval, serrate, small.

No. 2. Rotund, irregularly serrate.

No. 8. Obliquely ovate, obtuse, unequally serrate, appearing rather deformed.

***Ardisia mamillata*, Hance (fig. 505).**



FIG. 505.  
*Ardisia mamillata*.  
Seedling, showing  
emarginate coty-  
ledons. Nat. size.

*Primary root* very long, stout, tapering downwards and giving off numerous lateral branches.

*Hypocotyl* erect, very stout, fleshy, cylindrical or tapering somewhat to either end, minutely pubescent, 1 cm. long.

*Cotyledons* oblate, emarginate or obreniform, sessile, subfleshy, deep green, very hairy on both surfaces with transparent jointed hairs, which are longest on the upper surface and on the margin, convex above, revolute at the margin and concave beneath, showing a midrib very distinctly, but no other venation.

The emargination of the cotyledons appears to be due to their being convolute and closely wrapped or rolled round the plumule before emerging from the albuminous seed. The latter is round like a small pea, and the cotyledons, after attaining their full length, grow greatly in width and are accommodated in the seed by becoming convolute, as in *Geranium*, *Eucalyptus*, and others.

*Leaves* shortly penninerved, densely covered on the upper surface with mamillate outgrowths or emergences, upon which long coarse hairs are seated, oblong, obtuse, subcoriaceous, persistent.

***Ardisia polycephala*, Wall.**

*Fruit* a drupe, depresso-globose or considerably flattened at the top, smooth, deep black; epicarp thin; endocarp crustaceous and marked from base to apex with strong longitudinal nerves; mesocarp pulpy, reddish or pinkish; placenta basal, prominent and



protruding into the ovary, where it causes a cavity at the base of the seed, and thinning away towards the sides forms a cup round the same; it becomes brown and membranous when mature.

*Seed* globose, immersed in the basal placenta, and closely filling the cavity of the ovary, depressed or rather indented at the base by the prominent thickened placenta; testa extremely thin and membranous, pale brown.

*Endosperm* copious, subtransparent, fleshy when mature, horny when dry.

*Embryo* straight, cylindrical, transverse to the seed and parallel with the placenta, nearly equalling the width of the seed, colourless; cotyledons minute, ovate, obtuse, lying with their backs to the basal placenta and their tips just inside the periphery of the seed, and embedded in the endosperm; radicle nearly constituting the whole embryo, cylindrical, stout, obtuse, abutting against the testa on one side of the seed and even causing a slight prominence there.

#### EARLY DEVELOPMENT OF COTYLEDONS.

During germination the seeds, if but lightly buried, are carried up on the tip of the seedling; but if moderately deep in the soil, the hypocotyl rises with a curve and finally pulls itself out of the seed and becomes erect.

The cotyledons are now oblong, obtuse, concave and closely applied to each other by their edges or more or less distinctly convolute one over the other, densely glandular, sessile or subsessile, becoming shortly but distinctly petiolate, and greatly enlarged by the twenty-third day after germination.

They then unfold or unroll, becoming flat, elliptic-ovate, obtuse or subapiculate, obsoletely dentate at the margin, alternately and irregularly penninerved, reticulate with the principal nerves running into the minute teeth by a straight or zigzag course, or often sending strong lateral branches into them.

**Seedling** (fig. 506).

*Hypocotyl* 3-4 cm. long.

*Cotyledons* ultimately elliptic, obtuse, emarginate, coriaceous, evergreen, glabrous, persisting for about a year, petiolate, about 2.3 cm. long and 1.6 cm. wide.

The midrib is strong, traversing the leaf and tapering upwards till near the apical sinus, where it bifurcates, a branch passing on each side of the sinus also giving off numerous lateral, ascending, slightly wavy veins, furnished with branches uniting with one another towards the margin, and forming a series of large reticulations.

Apex ending in a few large pores and forming a small, somewhat crustaceous and brittle mucro crumbling away in old specimens, while the margin elsewhere remains intact.

Stomata large, numerous on the under side, fewer on the upper.



FIG. 506.—*Ardisia polycephala*. Half nat. size.

Resin or oil cavities rather numerous, brownish-orange, scattered and sunk in the tissue of the leaf.

*Leaves* coriaceous, persistent.

No. 1. Elliptic, obtuse, entire.

The ultimate ones exactly similar, but much larger. .

*Jacquinia ruscifolia*, Jacq.

*Hypocotyl* woody, erect, terete, shortly pubescent, dull green, 2 mm. above the soil.

*Cotyledons* oblong-ovate, undulate or curling, rigid, mucronate cartilaginous at the margin, deep green above, paler beneath, glabrous, sessile, 1.5 cm. long, 7 mm. wide.

*Stem* woody, erect, terete, subscabrous, pale green; 1st and 2nd internodes undeveloped.

*Leaves* verticillate, entire, glabrous, rigid, shining, deep green above, paler beneath, subrevolute at the margin, tipped with a spine, slightly subchannelled above, more or less carinate beneath; petioles rigid, 1-2 mm. long.

First pair opposite, elliptic.

Second pair opposite, scarcely decussate, elliptic, unequal, the smaller one lanceolate.

Here the first growth terminates, and several small brown scale-leaves are produced.

When growth recommences five narrowly lanceolate leaves are produced in a whorl; above this two small, narrowly lanceolate, opposite ones.

Here growth is again arrested, and the bud is protected with small scales.

## SAPOTACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 650.

*Fruit and Seed.*—The ovary is superior, and consists of two to five, rarely many, carpels cohering to form as many cells. The ovules are solitary in each cell, attached near the apex or at least some distance above the base of the axile placentas, and amphitropous. The hilum is ventral and usually very large. The fruit is baccate, pulpy, fleshy, more rarely thickened and dry or rarely thin, but always indehiscent. It contains as many cells as there are carpels, or by abortion it may be one-celled and one-seeded, in which case the seed is very large and conforms to the cavity. When the seeds are more numerous they are arranged around the central axis and flattened on their sides by mutual pressure. The hilum is often of great size, linear, oblong, or elliptic and frequently at least equalling the seed in length. Sometimes it is broad and confined to an area near the base of the seed. The testa is crustaceous or lignified, smooth and shining as in *Lucuma*. The embryo is straight with large cotyledons, and when endosperm is present they are flat and at right angles or parallel to the axis. When endosperm is wanting as in *Lucuma* the cotyledons are of great size and convexo-concave or variously squeezed into or overlapping one another at the edges. The radicle is always inferior and as a rule very minute compared with the cotyledons. The latter may be described as conferruminate in cases where endosperm is wanting and they attain a large size, as in a few species of *Lucuma*, but more decidedly in the genus *Sarcosperma* where the embryo is homogeneous and inseparable into its component parts. Other exceptions occur in *Argania*, in which the septa and axile placentas disappear during growth, and the whole of the seeds become agglomerated into a central mass. The testa of the seeds in *Labatia* and *Argania* is very thick and lignified, as is the case also in *Lucuma mammosa*. Endosperm is wanting in the latter and the large embryo conforms to the interior of the seed. The cotyledons are very fleshy and closely applied to one another,

but readily separable, and in germination swell up so as to burst the woody testa in halves.

In *Butyrospermum Parkii* the ovary consists of eight to ten carpels with as many cells, each of which contains one ovule. The fruit is one- or few-seeded by abortion. The fleshy cotyledons are plano-convex and inseparable from one another, forming a mass conforming to the seed, which is variable in outline, ovoid, oblong-ovoid, or almost globose, with an oblong or elliptic hilum broadest at the upper end. The radicle is short and scarcely protruded from between the cotyledons.

*Seedlings.*—There are two leading types in this Order according as the cotyledons are aerial or subterranean. The cotyledons vary in shape in both cases in conformity with the seed in which they were developed. Those of *Sideroxylon tomentosum* are broadly ovate, rounded at the base, obtuse at the apex, coriaceous, with an incurved penninerved venation similar to that of the leaves, and very persistent. They probably endure as long as the first leaves, seeing that they were still in perfect health a year and a half after germination. The cotyledons of *Mimusops Balata* are oblong-ovate, obscurely penninerved, coriaceous and also very persistent. The first four leaves are obovate-lanceolate.

The seedling of *Rostellaria abyssinica* is much smaller than either of the foregoing, with a finely pubescent hypocotyl. The cotyledons are suborbicular, emarginate, and faintly trinerved. The primary leaves are oval, entire, penninerved and opposite.

A strikingly different type is represented by an unnamed species of *Lucuma* (fig. 507). The cotyledons are oblong, plano-convex, or slightly concave on the upper surface, very fleshy and narrowed to a short petiole which is connate and forms an annulus around the axis. They are subterranean or partly so, but split the testa into halves and spread out horizontally, or one is directed upwards and the other downwards. When the upper surface is exposed to the light, it develops chlorophyll and becomes green. The extreme hairiness of the young stem and lanceolate-elliptic penninerved leaves in the seedling stage at least is very noticeable. The seedling of *Lucuma mammosa* is very similar to the last in all the

leading particulars. The cotyledons are subterranean and fleshy, but split open the woody testa during germination. The stem is very stout and is notable for the length of the first internode which measures 7–10 cm., and compensates for the want of the hypocotyl. The leaves are sometimes pseudoverticillate, but as a rule alternate, and the first six are closely aggregated above the first internode, oblong or lanceolate-elliptic and penninerved.

The cotyledons of *Butyrospermum Parkii* are fleshy and subterranean like those of *Lucuma*; but the first three or four leaves are small, scale-like, and caducous, while their stipules are more persistent. The next two or three are foliaceous, elliptic and penninerved.

***Chrysophyllum oliviforme, Lam.***

*Primary root* long, tapering, with lateral rootlets.

*Hypocotyl* erect, terete, glabrous, soon becoming woody, 3.5–4.5 cm. long.

*Cotyledons* oval, obtuse, entire, shortly petiolate, obscurely trinerved, opaque, fleshy, deep olive-green and convex above, much paler beneath and sometimes slightly concave, glabrous, often irregular in outline, often shortened at the apex, and in other cases somewhat oblique; petiole plano-convex or slightly grooved above.

*Stem* erect, terete, or slightly compressed in the seedling, covered with a pale brown or yellowish, adpressed pubescence; 1st internode 4 mm. long.

*Leaves* simple, entire, cauline, alternate except the primary ones, shortly petiolate, exstipulate, penninerved, with the nerves incurved and not reaching the margin; petiole subterete, channelled above, covered with an adpressed pubescence.

No. 1. Lanceolate, acuminate, ciliate at the margin, slightly hairy on the ribs above at least when young, and covered with a silky adpressed pubescence beneath.

***Lucuma mammosa, Gaertn.***

*Seed* very large, elliptic, with a smooth woody testa.

*Hypocotyl* undeveloped, or short and subterranean.

*Cotyledons* conforming to the interior of the testa, fleshy, plano-convex, or slightly concave above, splitting open the testa during germination, but remaining in it and subterranean.

*Stem* stout, erect, purple-brown, pubescent, soon becoming woody; 1st internode 7-10 cm. long; several succeeding ones short. The long first internode is to make up for the non-development of the hypocotyl.

*Leaves* thinly pubescent.

Nos. 1-6. Oblong or lanceolate-elliptic, rather crowded above the first internode.

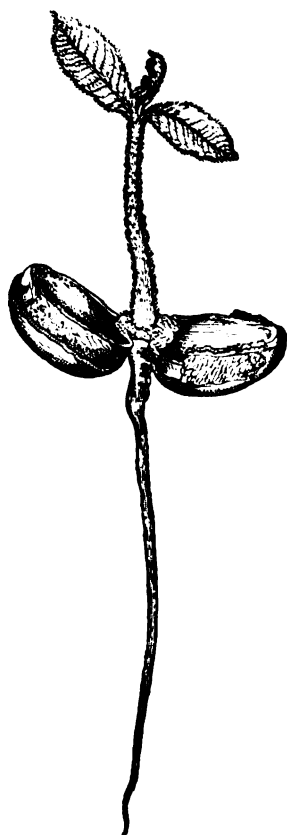


FIG. 507.—*Lucuma* sp. Showing the two halves of the testa attached to the cotyledons. Half nat. size.

*Lucuma* sp. (fig. 507).

*Primary root* long, stout, tapering downwards and quite unbranched in the early stages.

*Hypocotyl* very short, stout, subterranean.

*Cotyledons* very large, fleshy, plano-convex or slightly concave on the upper surface, sessile or narrowed to very short petioles which are connate around the axis, subterranean or appearing just at the surface of the soil, bursting the woody testa into two halves and spreading horizontally, or often one becomes suberect while the other is deflexed; lamina 8-8.6 cm. long, 1.8-2 cm. wide, about 1.2 cm. thick, and becoming deep green on the upper surface when exposed to light.

*Stem* erect, stout from the earliest stages, and soon becoming woody, densely hairy or subvillous, terete or tapering upwards; 1st internode 5-6 cm. long; 2nd very much shorter.

*Leaves* as in *Chrysophyllum* but with parallel slender veins, showing most prominently on the under surface, ultimately coriaceous; petioles terete or subterete, densely hairy.

First pair opposite, rather small, unequal, showing that they are not truly opposite, lanceolate-elliptic, acute, slightly undulated at the margin at least when young.

No. 3. Alternate.

***Sideroxylon tomentosum*, Roxb.**

*Hypocotyl* 8-4 cm. long, 2.5-3.5 mm. thick, terete, woody, glabrous, greyish-brown.

*Cotyledons* nearly equal, shortly stalked, about 3 cm. long and 2 cm. wide, ovate, rounded at the base, very obtuse at the apex, entire, pinnatinerved, coriaceous, glabrous, dark dull green above, light green beneath, very persistent, for when examined eighteen months after germination they were still in perfect condition.

*Stem* like the hypocotyl, decreasing in thickness and increasing in pubescence towards the top; internodes 5-15 mm. long, flexuose.

*Leaves* entire, alternate, subreticulate, coriaceous, tomentose when young, glabrous when old; petioles short, flattened above.

Nos. 1-12. Elliptic or oblanceolate, acuminate, entire, pinnatinerved, coriaceous, pubescent when young, dark green; lamina 4-6 cm. long, and 1.5-2 cm. wide; petiole short, stout, pubescent, often reddish, with a spine in its axil.

Ultimate leaves lanceolate-elliptic, acute, glabrous and shining on both surfaces, deep green above, lighter beneath, evergreen, alternately penninerved with ascending nerves. Many of the branches are reduced to spines one-half to three-quarters or one inch long.

***Mimusops Balata*, Gaertn.**

*Hypocotyl* well developed and woody at an early stage.

*Cotyledons* very large, foliaceous, broadly oblong-ovate, obtuse, sessile, obscurely penninerved with slender ascending nerves, coriaceous, dark green, glabrous, very persistent.

*Stem* woody.

*Leaves* simple, entire, alternate, exstipulate, shortly petiolate, obscurely penninerved with slender nerves, coriaceous, persistent.

Nos. 1-4. Inclusive, obovate-lanceolate, shortly petiolate, somewhat acuminate.

***Butyrospermum Parkii*, Kotschy.**

*Ovary* of eight to ten carpels, eight- to ten-celled, each cell one-ovuled; ovules fixed by their ventral aspect to the axis, amphitropous; micropyle inferior.

*Fruit* ellipsoid, baccate, one- or few-seeded by abortion; pericarp thin, fleshy.

*Seed* ovoid or oblong-ovoid, or sometimes almost semiglobose when it is flattened on the ventral aspect by pressure or contact with other seeds or parts of the fruit; testa brown, smooth,

shining, crustaceous, and brittle ; hilum on the ventral aspect, very large, oblong or elliptic, narrowed to an acute point at the lower end, but always broader and rounded at the upper end, and nearly or quite equalling the length of the seed ; raphe ventral ; radicle and micropyle inferior ; chalaza subapical on the ventral aspect.

*Endosperm* absent.

*Embryo* straight, large, entirely filling the interior of the seed and conforming to its shape when mature, or loose and free by shrinking ; cotyledons very thick, fleshy, plano-convex, applied to each other face to face and (in old seeds at least) inseparable, each occupying half the space in the seed, of variable outline like the seed, but always broadest at their bases, which rest on the lower end of the seed ; radicle very slightly protruded from between their bases, short, stout.

### Seedling.

*Hypocotyl* undeveloped.

*Cotyledons* thick, fleshy, subterranean.

*Stem* erect, woody, hairy.

*Leaves* slightly coriaceous, persistent, covered with rusty hairs when young.

Nos. 1-3 or 4. Alternate, small, scale-like, caducous, linear-subulate, stipulate ; stipules more persistent than the leaves.

Nos. 4-6. Much larger, foliaceous, elliptic, penninerved with incurved nerves, glabrous, with short hairy petioles channelled above. Stipules very hairy, protecting the sides of the bud.

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## EBENACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 662.

*Fruit and Seed*.—The ovary is superior, sessile or rarely stipitate, consisting of two to eight carpels uniting to form as many cells, or twice the number by development of spurious and perfect or imperfect septa. The ovules are geminate in each, or twice the number of the carpels ; but when false dissepiments are present the ovules are solitary in each cell ; in all cases they are inserted upon axile placentas, pendulous and anatropous. The pericarp is coriaceous or fleshy and indehiscent, rarely dehiscent, and the fruit often



few-celled by abortion and one- or few-seeded. The seeds are pendulous, more or less compressed and oblong, or if solitary globose, two- to three-furrowed on the back, with a membranous or coriaceous testa. Endosperm is copious, cartilaginous, and in many cases ruminated. The embryo is axile, and straight, oblique or slightly curved, and half the length of the endosperm or longer. The cotyledons are foliaceous and much wider than the superior cylindrical radicle.

*Seedlings*.—The cotyledons of *Diospyros Embryopteris* (fig. 508) are lanceolate-oblong, entire, trinerved, the nerves giving off short branches. The first pair of leaves are opposite, obovate-oblong, with a closely anastomosing venation. The ultimate leaves are lanceolate-oblong, coriaceous, entire, with ascending slightly incurved venation. In an unnamed species of *Diospyros* the cotyledons are ovate, trinerved from a little above the base, and 2–5 cm. long exclusive of the short petiole. The first twelve internodes of the stem are short, after which the primary axis becomes arrested and branches are developed horizontally from axillary buds a little below the apex which bears minute scale-like leaves. Previous to this ten ovate leaves are produced with incurved venation.

***Diospyros Embryopteris*, Pers. (fig. 508).**

*Hypocotyl* erect, subcompressed, but possibly accidentally, longitudinally ridged and furrowed, glabrous, straw-coloured, about 4 cm. above the soil.

*Cotyledons* lanceolate-oblong, obtuse, entire, narrowed somewhat to the base and sessile, glabrous, three- or faintly five- to seven-nerved with slightly branching nerves, thin, 1.9–2.2 cm. long, 6–7.5 mm. wide.

*Stem* erect, subcompressed, densely covered with ascending pale brown hairs, ultimately woody; 1st internode 9 mm. long.

*Leaves* simple, entire, cauline, opposite in the seedling stage, ultimately alternate, exstipulate, petiolate, alternately and ascendingly penninerved, much reticulated, glabrous above, ciliate at the margin, and thinly covered beneath with adpressed hairs, coriaceous, evergreen; petioles very short, semiterete, flattened and shallowly grooved or channelled above, densely hairy in the seedling but less in the adult plant or glabrescent.

First pair obovate-oblong, obtuse, narrowed towards the base.

Ultimate leaves lanceolate-oblong, subacuminate, obtuse, shortly petiolate, subundulate at the margin, coriaceous, alternately and sharply ascendingly penninerved, very reticulate, glabrous above, thinly covered with adpressed hairs beneath or glabrescent, shining on both surfaces, deep green above, lighter green with a few large glands beneath.

**Diospyros sp.**

*Hypocotyl* woody, erect, terete, pubescent, soon becoming brown or almost black, 8·8 cm. or more above soil.

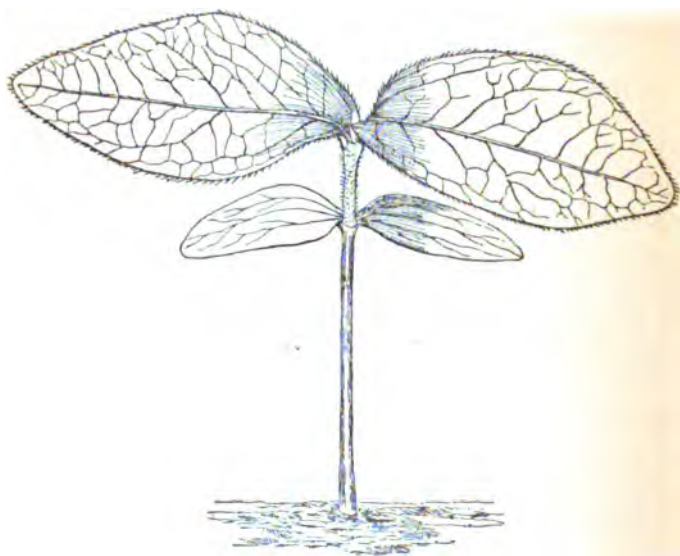


FIG. 508.—*Diospyros Embryopteris*. Nat. size.

*Cotyledons* large, foliaceous, ovate, obtuse, trinerved, shortly petiolate, coriaceous, thin, pubescent on the midrib above, otherwise glabrous, deep green above, much paler beneath; lamina 2–5 cm. long, 1·6 cm. wide; petiole grooved and pubescent above with a prominent midrib, shallowly convex on the back, 2 mm. long.

*Stem* woody, erect, terete, densely pubescent, pale green, soon becoming arrested and producing long, lateral, horizontal or slightly ascending, flexuose branches; 1st internode 1·5 mm. long; 2nd 1 mm.; 3rd 4·25 mm.; 4th to 7th inclusive 3·5 mm.; 8th 3 mm.; 9th 4 mm.; 10th 1·5 mm.; 11th and 12th undeveloped. Here

growth becomes arrested in this specimen, and a branch is produced in the axil of the ninth and tenth leaf respectively.

*Leaves* alternate and scattered on the stem, alternate and distichous on the branches, alternately penninerved with ascending nerves, ciliate, pubescent, dull green above, paler beneath; petioles very short, 1-1.5 mm. long, flattened or slightly grooved above, densely pubescent.

Nos. 1-10. Small, ovate, obtuse, much smaller than the cotyledons.

Nos. 11 and 12. Minute and scale-like.

Lower branch leaves small, obtuse; upper ones larger, ovate-lanceolate, obtuse.

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## STYRACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 666.

*Fruit and Seed.*—The ovary is inferior, or half, or wholly superior, consisting of two to five carpels cohering to form an ovary with as many cells, or the septa may become torn away from the axis while the plants are yet in flower, making one cavity. The ovules are solitary or few in each cell, attached to axile placentas, erect or pendulous and anatropous. The fruit is often baccate or drupaceous, and one-seeded by abortion, or it may contain from two to four seeds in one cell. In some cases the pericarp becomes hardened and ultimately splits open by three valves as in some species of *Styrax*. The testa of the seed is membranous or coriaceous, with frequently a broad hilum. Endosperm is more or less copious and fleshy or almost horny. The embryo is axile and straight, or more or less curved in some species of *Symplocos*, nearly equalling the endosperm in length, with the two cotyledons linear, plano-convex or together forming a terete body, or broad and flat with a short or elongated radicle.

The fruit of *Halesia hispida* is inferior and dry when mature, one- to three-celled and one- to three-seeded and indehiscent. The seeds are pendulous, with a large straight embryo, with oblong cotyledons rather narrower than the endosperm, plano-convex and somewhat flattened. The radicle is

terete and slightly longer, but narrower than the cotyledons. In *Symplocos paniculata* (fig. 509) the seed is reniform and the embryo curved in conformity with it. The cotyledons are linear and not broader than the radicle. Only ten out of one hundred and sixty species have the seed and embryo so decidedly curved as in this instance. The fruit of *Styrax* is almost or wholly superior, and three-celled with a few seeds in each cell, attached near the base of the axile placentas. It is subdrupaceous and globose, but when mature may readily be split into three valves. It becomes one-celled and one-seeded, however, at an early stage by abortion. The seed is large, and globose with a thick crustaceous or woody testa. The embryo is straight and nearly equals the length and width of the endosperm. The cotyledons are broadly ovate, five-nerved and reticulate, somewhat longer than the terete radicle and several times wider.

*Seedlings*.—Few of these have been observed, but the character of the seedling may generally be surmised from that of the seeds. Two very distinct types at least may be noticed. The embryo is terete and straight or curved in *Symplocos* and the endocarp is frequently lignified. This is the case in *S. paniculata* (fig. 509), and the germinating embryo has to make its exit through a small round hole at one end of the endocarp. The cotyledons are slightly unequal in length, owing to their being strongly curved in conformity with the seed, and they are also narrowly linear, owing to its narrowness. This shape is also necessary in order to permit of their escape from the endocarp and seed. The leaves are alternate and the first two are elliptic and distantly serrate.

The cotyledons of *Styrax japonica* are foliaceous, broadly oblong-oval or elliptic, and trinerved, with all the nerves branching upwards similar to those of the leaves. The first three leaves are ovate-lanceolate, and distantly serrated on the margins.

*Symplocos paniculata*, Wall. (fig. 509).

*Primary root* of great length, with a few rootlets only in the young stage near the base.

*Hypocotyl* erect, terete, glabrous, pale green, arched at the top in germination, ultimately 2-2.7 cm. long.

*Cotyledons* unequal in length, linear, obtuse, sessile and slightly connate at the base, glabrous with a channelled midrib above, and slightly convex on the back; the longer 8-9.5 mm. long; the shorter 7-8 mm. long; both 1-1.25 mm. wide.

The endocarp of the fruit is obovoid, woody, and does not burst during germination. The radicle emerges by a small hole at the narrow end, the hypocotyl elongates, becoming curved and finally straightening, carrying up with it the endocarp containing the seed. As the cotyledons elongate they push out at the small hole in the endocarp, and finally get free and spread out to the light.

The cotyledons owe their shape to that of the seed which is

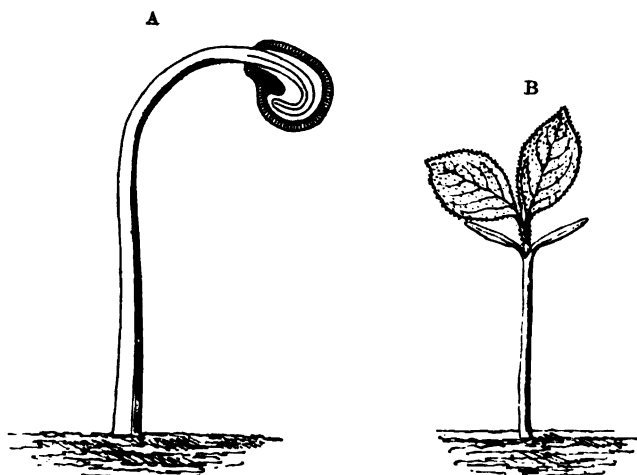


FIG. 509.—*Symplocos paniculata*. A, germinating seedling with vertical section of endocarp and seed, showing mode of exit of embryo,  $\times 2$ . B, seedling (nat. size).

reniform or curved, and contains a large quantity of fleshy endosperm. If a seed is cut open during germination the cotyledons are found to be linear, obtuse and, together with the apex of the hypocotyl, curved like the head of a shepherd's staff. Their shape then might be accounted for by the shape of the seed, the quantity of endosperm originally surrounding them, and thirdly by the difficulty that broad cotyledons would experience in getting out of the indehiscent endocarp.

*Stem* erect, terete, hairy with upwardly incurving colourless hairs; 1st internode 2-4 mm. long; 2nd much shorter.

*Leaves* simple, alternate, exstipulate, very shortly petiolate, penninerved with ascending, incurved nerves, hairy on both surfaces.

Nos. 1 and 2. Elliptic, acute, shallowly and distantly serrate above the middle, tapering at the base, decurrent and forming a narrow wing to the short petiole.

*Halesia hispida*, *Benth. et Hook.*

*Pistil* syncarpous, inferior ; ovary of three carpels, three-celled, many-ovuled ; ovules seated on the middle of the placenta with the superior ones ascending, and the lower ones pendulous, anatropous ; micropyle inferior and superior accordingly.

*Fruit* subfleshy when young, becoming dry when mature, indehiscent, crowned with the persistent calyx-teeth, densely covered with stiff, bristly, spreading, more or less brittle and easily detached hairs, one- to three-celled, one- to three-seeded by abortion ; when reduced to one or two, the seeds do not occupy the whole interior of the fruit. The pendulous anatropous ovules in the lower part of the ovary seem to be most often fertilised and to reach maturity. Endocarp hard and woody.

*Seed* oblong, slightly narrowed at either end, conforming to the interior of one cell, and often somewhat oblique to the longitudinal axis of the fruit ; testa comparatively thin, and much more so than the endocarp ; hilum and micropyle superior and contiguous in the pendulous seeds.

*Endosperm* copious, fleshy, white.

*Embryo* comparatively large, straight, embedded in and falling a little short of the endosperm, colourless ; cotyledons oblong, obtuse, entire, slightly narrowed towards the apex, plano-convex, and closely applied face to face, lying in the broader axis of the seeds when the latter are in any way compressed, with their backs to the axis ; radicle terete, obtuse, stout, somewhat longer than the cotyledons, and lying with its point close to the base of the endosperm.

*Styrax officinale*, *L.*

*Pistil* syncarpous, almost or wholly superior, fixed with a broad base to the receptacle ; ovary of three carpels, three-celled with each cell five-ovuled ; ovules basal, erect from the inner angles of the cells, anatropous ; micropyle inferior.

*Fruit* globose, splitting when mature into three valves, glabrous, fixed with a broadish base to the receptacle, and surrounded there by the calyx, one-celled at an early stage by the rupturing of the septa, one-seeded ; epicarp and endocarp subcoriaceous ; mesocarp fleshy.

*Seed* subglobose, slightly depressed and a little broader than

deep, basal, erect, marked longitudinally or in a radiating manner from the hilum to the apex by three shallow furrows and three slender intermediate and equidistant ridges ending in a small elevated point, and all corresponding to their counterparts on the inner face and apex of the pericarp; testa very thick, crustaceous or almost horny or bony, pale brown and shining; tegmen thin, pale, membranous; hilum basal, depressed, pale-coloured, rather conspicuous; raphe and chalaza indiscernible in the mature seed.

*Endosperm* copious, fleshy, white when moist and becoming pale yellow, prominent at the micropyle and pushed a little way into the testa.

*Embryo* nearly as long as the endosperm, slightly curved, similar to the endosperm in colour; cotyledons broadly ovate, obtuse, entire, flat or nearly so, about equalling or slightly longer than the radicle and less in diameter, lying in the endosperm with their backs to the placenta, and somewhat transverse or obliquely transverse to the latter with five incurving nerves at the base, anastomosing towards the margin; radicle cylindrical, pointing to the micropyle, contiguous to and on one side of the hilum, its tip projecting into the projecting part of the endosperm, piercing the testa at the micropyle.

***Styrax japonicum*, Sieb. et Zucc.**

*Hypocotyl* erect, terete, about 4 cm. long, with a few minute hairs, light green or colourless.

*Cotyledons* broadly oblong-oval, obtuse, entire, petiolate with short flat petioles, glabrous, dark green, distinctly pinnatinerved like the leaves.

*Stem* erect, terete, herbaceous, ultimately woody, hispid; 1st internode 1 cm. long; 2nd about 5–6 mm.

*First leaves* simple, cauline, alternate, exstipulate, shortly petiolate, lanceolate, acuminate, rather serrated on the edges, obtuse, hispid, distinctly pinnatinerved.

## OLEACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 672.

*Fruit and Seed.*—The ovary is superior, of two carpels, syncarpous and two-celled. The ovules are usually geminate in each cell, rarely solitary or four to eight, attached to the base or the apex of the dissepiment and amphitropous or more often anatropous, with a superior micropyle when inserted at the apex of the septa. The fruit is capsular, dehiscing loculicidally by two valves, or baccate or drupaceous. The seeds vary from two to four, but are usually solitary by abortion in each cell, and erect or pendulous. The testa is usually membranous, rarely slightly thickened. Endosperm is usually abundant, and fleshy, hardened or somewhat horny, or oily; rarely is it entirely absent as in *Schrebera* or in some species of *Linociera*. The embryo is straight and axile with flat and ovate or oblong cotyledons when endosperm is present, and thick and fleshy ones when the latter is absent. The radicle is generally short and sometimes surrounded by the cotyledons, rarely elongated, and superior or inferior according to the insertion of the seed. A few exceptions to the above characters are met with in some species. A tricarpellary ovary sometimes occurs in *Fontanesia* and *Nyctanthus*. Endosperm is wanting as above mentioned in *Schrebera*, and the cotyledons are plano-convex but much twisted. The radicle is inferior and considerably elongated in *Myxopyrum*. The seed is pendulous and anatropous in *Syringa vulgaris*, and solitary by abortion in a capsular fruit. The embryo nearly equals the endosperm in length and has oblong flat cotyledons about twice the length of the radicle. The embryo is much shorter, and in fact scarcely half the length of the endosperm in the mature seed of *Fraxinus excelsior* (fig. 511), and the cotyledons are oblong or oblong-lanceolate, obtuse or entire with numerous alternate, incurved nerves uniting with one another within the margin. This latter character is best seen in the embryo (fig. 511) which is preparing for germination and has almost filled the seed. The latter is very much flattened laterally and fills the cavity



of the seed-vessel which develops into a samaroid fruit with a wing at the apex in line with its longitudinal axis. The narrow septum becomes ruptured from the walls of the cells during growth and appears like a greatly elongated funicle in the mature fruit. Three out of four ovules become atrophied at an early age, and their remains may be seen close to the short true funicle.

The characters of the young ovary of *Ligustrum japonicum* are very similar to those of *Fraxinus*, but the ovules are inserted a little below the apex of the placenta.

The fruit, however, is globose and drupaceous, with a globular seed conforming to the interior of the cavity. The embryo is nearly as long as the endosperm, with orbicular cotyledons about equalling the slightly curved radicle.

*Seedlings*.—The shape of the cotyledons and their length have direct relation to the seeds from whence they are derived, but they may undergo some slight alteration during and after germination. They are enabled to increase greatly in size by feeding upon the endosperm before leaving the seed, and may also profit from the latter by storage of plastic material. At least three fairly distinct types have come under my notice, namely, ovate, oblong, and oval cotyledons.

Those of *Forsythia suspensa* (fig. 510) are ovate or oblong-ovate, emarginate and obscurely penninerved. The first pair of leaves are ovate and serrate. The majority of the adult leaves are ovate, but many pinnately trifoliate ones occur on the same plant or even the same shoot bearing the more typical form. They are, therefore, rather strikingly dimorphic.

The second type, with oblong cotyledons, is met with in *Fraxinus excelsior* (fig. 512). The first pair of leaves are ovate and serrate, but the second pair are pinnately trifoliate, while succeeding ones gradually acquire a greater number of leaflets making an imparipinnate leaf. The cotyledons of *F. Sogdiana* are broadly oblong and penninerved with a branching venation. The first pair of leaves are like those of *F. excelsior*, but the second pair are lanceolate-cuneate and serrated above the middle.

The cotyledons of *Ligustrum japonicum* represent the oval

type, and the penninerved venation is similar to that of the leaves in the last case. The first pair of leaves are oblong-oval and obtuse; but the ultimate leaves are ovate or elliptic, more pointed and coriaceous. The seedling of *L. robustum* is similar in all important points to that of *L. japonicum*, but the cotyledons are perhaps more distinctly emarginate. The first two pairs of leaves are lanceolate-elliptic.

***Forsythia suspensa*, Vahl (fig. 510).**

*Primary root* a perennial, woody, long taproot, with long, distant horizontal fibres, almost smooth.

*Hypocotyl* firm, 1.5–2 cm. long, 1 mm. thick, terete, glabrous, brown.

*Cotyledons* with swollen buds in their axils equal, 1.5–2 cm. long, 6–9 mm. wide, emarginate, oblong-ovate, cuneate at the base, concave, obscurely pinnatinerved, firm but not very thick, glabrous, dull yellowish-green.

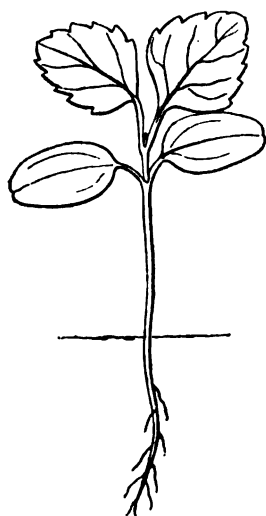


FIG. 510.  
*Forsythia suspensa*.  
Nat. size.

*Stem* erect, terete, glabrous, ultimately woody, rough with lenticels.

*Leaves* simple or compound, serrate, cauline, opposite, exstipulate, petiolate, with alternate or sometimes subopposite, ascending nerves, glabrous, deep green above, paler or subglaucous beneath; petioles channelled above, semiterete, dilated at the base, and articulated with the stem.

The first and second pairs are broadly ovate, obtuse, serrate, and penninerved.

Ultimate leaves very variable on the same branch, and simple or compound often mixed even on vigorous branches; simple ones ovate or subcordate, acute, or in some instances rotund-ovate, obtuse; compound ones pinnately trifoliate; terminal leaflet ovate, acute, cuneate at the base; lateral leaflets much smaller, elliptic, acute, unequal at the base, or obovate and obtuse or acute, variable.

***Syringa vulgaris*, L.**

*Ovary* two-celled, with one ovule in each cell; ovules anatropous; micropyle superior.

*Fruit* a two-celled capsule, dehiscing at the apex, one seed in each cell.

*Seeds* oblong, smooth, winged, laterally flattened, 8–10 mm. long ; hilum inconspicuous, basal.

*Endosperm* copious, fleshy, white, surrounding the embryo.

*Embryo* straight, nearly equal in length to the endosperm, colourless ; cotyledons oval, obtuse, entire, rather narrow, plano-convex ; radicle terete, obtuse, slightly shorter than the cotyledons, close to the hilum and pointing to the upper end of the seed.

*Fraxinus excelsior*, L. (fig. 511).

*Ovary* two-celled, each cell two-ovuled ; ovules pendulous from the top of the cells, anatropous ; micropyle superior.

*Fruit* a samara, linear-oblong, obtuse, nearly always obliquely emarginate, laterally much compressed and thin, produced at the apex into a thin wing, glabrous, striated longitudinally with nerves, one-celled by the rupture of the septum, one-seeded by abortion, indehiscent ; septum in the narrow way of the fruit, soon becoming ruptured and bearing at its apex three aborted ovules and one fertile seed.

*Seed* oblong, obtuse, slightly narrowed at both ends, much compressed laterally, thin, striated or shallowly furrowed longitudinally, deep brown, conforming in shape to the interior of the fruit, suspended from the apex of the septum or placenta by a curved funicle which is persistent ; raphe dorsal, passing round the dorsal edge to the chalaza at the apex of the seed ; micropyle and radicle superior.

*Endosperm* copious, fleshy, pale or colourless, and subtransparent.

*Embryo* straight, flat, comparatively small, embedded in the endosperm at the upper or basal end of the seed ; cotyledons oblong, obtuse, entire, narrowed somewhat to the base, flat, closely adpressed, face to face ; radicle stout, obtuse, somewhat shorter than the cotyledons, close to the micropyle at the upper end of the seed, but within the endosperm.

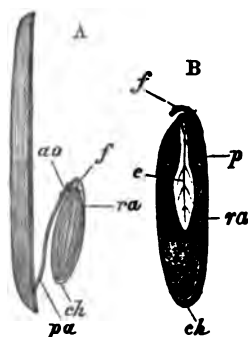


FIG. 511.—*Fraxinus excelsior*. A, samara with half removed and the seed pulled out (nat. size): pa, placental axis; ao, aborted ovules; f, funicle; ra, raphe; ch, chalaza. B, longitudinal section of seed,  $\times 2$ : f, funicle; p, endosperm; e, embryo; ra, raphe; ch, chalaza.

**Seedling (fig. 512).**

*Primary root* tapering downwards, with numerous flexuose, fibrous, lateral rootlets.

*Hypocotyl* erect, terete, glabrous, soon becoming woody and grey, variable in length, 4–6 cm. long or more.

*Cotyledons* oblong, obtuse, shortly petioled, entire, alternately but obscurely penninerved, with a distinct midrib, glabrous, variable in size; lamina 1.7–2 cm. long, 6–9 mm. wide.



FIG. 512.—*Frazinus excelsior*. A. Nat. size. B. An older seedling; the cotyledons have dropped. Two-thirds nat. size.

*Stem* woody, erect, terete, glabrous, pale green, becoming grey; 1st internode 6–10 mm. long; 2nd 6–8 mm.

*Leaves* compound (first simple), cauline, opposite, exstipulate, petiolate, minutely ciliate, ultimately glabrous at the margin, but in the leaves of the adult tree woolly at the junction of the lateral veins with the midrib beneath on the basal quarter of the leaflets, bright green and shining above, pale beneath and finely reticulate; petioles flattened above, dilated and thickened at the base, scarcely grooved.

First pair ovate, acute, serrate, simple, rarely lobed at the base.

Second pair pinnately trifoliate; leaflets elliptic, acute, serrate above the middle, articulated with the rachis; terminal one largest.

Ultimate leaves imparipinnate, with three to five or more pairs of leaflets and a terminal one; lowest pair of leaflets lanceolate; terminal one lanceolate-elliptic; the rest oblong; all acuminate, with a narrow cartilaginous margin, rather distantly and unequally serrate, with acute serratures, hooked inwards at their tips, alternately penninerved, sessile, cuneate at the base; rachis narrowly channelled above, or margined, or winged, rounded on the back, much thickened at the insertion of the leaflets.

***Fraxinus Sogdiana*, Bge.**

*Hypocotyl* erect, terete, glabrous, 1-2 cm. long, brown.

*Cotyledons* very similar to those of *F. excelsior*.

*Stem* erect, quadrangular, herbaceous, ultimately woody; 1st internode 7-10 mm. long; 2nd about the same.

*First leaves* simple, opposite, decussate, ovate or almost lanceolate, acute, coarsely serrate, glabrous, green, pinnatinerved; petioles rather short and broad, channelled on the upper face.

***Olea cuspidata*, Wall. (fig. 518).**

*Hypocotyl* shrubby, erect, terete, glabrous, brownish, 1.2 cm. above the soil.

*Cotyledons* ovate, obtuse, entire, or usually slightly obliquely emarginate, penninerved, coriaceous, persistent, deep opaque green, paler beneath, glabrous, shortly petiolate; lamina 1.85 cm. long, 7.5 mm. wide; petiole channelled above, .5-1 mm. long.

*Stem* shrubby, erect, terete, densely and shortly pubescent, greyish; 1st internode 8.5 mm. long; 2nd 5 mm.; 3rd 7 mm.; 4th 9.25 mm.; 5th 11 mm.

*Leaves* simple, entire, cauline, opposite, decussate, exstipulate, shortly petiolate, scaly on both surfaces when young, ultimately glabrous or nearly so except the shortly ciliate margin, deep green and shining above, paler beneath, coriaceous, linear-lanceolate,

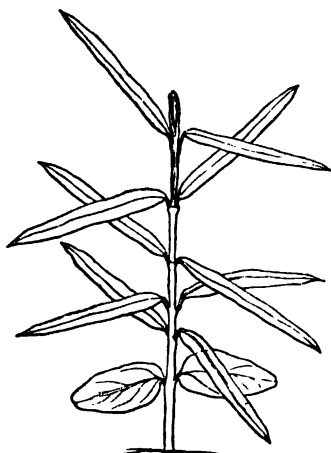


FIG. 518.—*Olea cuspidata*.  
Two-thirds nat. size.

acute or cuspidate, usually all similar in seedling stage, at any rate up to the sixth pair.

*Olea cuspidata* belongs to the type with ovate cotyledons, which closely resemble those of *Forsythia suspensa*. They are remarkable although by no means unique amongst the Phanerogamia in being broader than the first six pairs of leaves. Other instances of this relation of the cotyledons to the primary leaves may be found amongst the Cactææ, Asclepiadææ and Proteacææ.

***Ligustrum japonicum*, Thunb.**

*Fruit* a globose, one-seeded berry.

*Seed* obovate or globose, conforming in shape to the fruit, slightly flattened laterally, 3–4 mm. in diameter; hilum rather conspicuous; testa brownish.

*Endosperm* copious, surrounding the embryo, greyish-white or colourless.

*Embryo* straight, embedded in the endosperm, colourless; cotyledons suborbicular or oblong, obtuse, entire, closely adpressed; radicle, terete, obtuse, situated with its tip near the hilum.

**Seedling.**

*Hypocotyl* erect, terete, covered with very minute hairs, light green or almost colourless, 2–3 cm. long.

*Cotyledons* broadly oblong, obtuse, entire or minutely emarginate, petiolate, glabrous, light green, pinnatinerved like the leaves.

*Stem* erect, terete, covered with minute hairs, herbaceous, ultimately woody; 1st internode 6–10 mm. long.

*First leaves* simple, entire, cauline, opposite, shortly petiolate, exstipulate, oblong-oval, subacute, covered with minute hairs, light green, pinnatinerved.

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## APOCYNACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 681.

*Fruit and Seed*.—The ovary is superior and free, or more rarely half immersed in the receptacle, consisting of two carpels united by their edges, forming one cell with parietal placentas, or completely uniting to form axile placentas, while in a third type they are connate by their bases only or quite separate, with the placentas on the middle of the ventral suture. The

ovules in each carpel are usually geminate or few and arranged in a double series, or indefinite and arranged in many series, very rarely solitary. They are frequently inserted by the ventral surface, peltate and amphitropous, or almost anatropous and pendulous, very seldom erect as in some species of *Acokanthera* and *Vallesia*. The fruit may consist of one undivided piece, and be indehiscent, fleshy or rarely dry and hard or samaroid; in many other cases the two carpels are merely united at the base or are entirely free, and the fruit is baccate, drupaceous and indehiscent, or follicular and dehiscing by the ventral suture, liberating the linear placentas. Rarely the fruit is united into one piece or the carpels dehisce by two valves. The seed is very variable in outline, and is sometimes peltate and sessile, but oftener more or less compressed with the ventral face flat or concave, and affixed to the placenta by the middle or higher up by a filiform funicle. The testa is membranous or subcoriaceous and occasionally produced into a wing, or develops at one or both ends into a tuft of long cottony hairs. The endosperm is fleshy or almost cartilaginous, but is often restricted to a thin layer and sometimes entirely absent. The embryo is large, straight, and almost equals the endosperm in length as well as width, with foliaceous and flat, concave, rarely convolute or twisted cotyledons. The radicle is terete and shorter, rarely longer than the cotyledons and superior, very rarely pointing to the base of the fruit. There are several exceptions to the general rule in the Order. Undivided and dehiscent fruits occur in *Chilocarpus* and *Allamanda*, with distinct carpels dehiscing by two valves in *Aspidosperma*. Endosperm is wanting in *Aspidosperma*, *Willughbeia*, *Cerbera* and allied genera, *Leuconotis* and *Carpodinus*; it is ruminated in *Alyxia* and in several other genera of the tribe *Plumeriæ*. The margins of the cotyledons are infolded in *Adenium*, folded together in *Holarrhena*, convolute in *Wrightia*, and much twisted in *Kickxia*. The radicle is inferior in *Vallesia* and some species of *Rauwolfia*. *Acokanthera Thunbergii* is notable for its baccate two-celled fruit, containing a large peltate seed in each cavity. The cotyledons of the embryo are foliaceous, roundly ovate and petiolate, about equalling the radicle and petioles in length.

*Seedlings*.—At least three or four different types of cotyledons may be observed amongst seedlings of this Order, and speaking generally they may be described as large and foliaceous, a fact to be accounted for by the large and flattened seeds and the great size of the embryo. The cotyledons of *Thevetia neriifolia* are suborbicular and compressed while yet in the seed, but they had dropped before the seedling was observed. The first ten leaves are linear-lanceolate and acuminate, longer and no doubt narrower than the cotyledons. A type with oblong, penninerved and reticulate cotyledons is met with in *Echites umbellata* (fig. 515). The first two pairs of leaves are ovate, larger than the cotyledons, but have a very similar venation. The cotyledons of *Wrightia tinctoria* are also oblong with a penninerved venation similar to that of the leaves, but they are unequal, a fact probably to be accounted for by their being convolute in the seed. The first five pairs of leaves are lanceolate, obtuse, larger and broader than the cotyledons. *Parameria glandulifera* represents a type with ovate cotyledons. The first three or four pairs of leaves are lanceolate-elliptic, acuminate. The first two or three pairs of *Mandevilla suaveolens* are lanceolate and narrower than the broadly ovate cotyledons which have a similar incurved venation. The ultimate leaves are oblong-cordate and finely acuminate.

The fourth type to be noted is represented by *Plumeria alba* (fig. 514) which has oblong-cordate, trinerved cotyledons, the basal auricles of which are frequently unequal. They attain this shape while yet in the seed. The first pair of leaves are oblong-lanceolate and opposite, followed by four others which are similar but larger, and alternate. The cotyledons of *Tabernæmontana amygdalifolia* differ from those of the last in being broadly triangular and subcordate at the base, with a venation similar to that of the leaves. The first two pairs of the latter are opposite, and broadly lanceolate or ovate.

***Acokanthera Thunbergii*, Benth. et Hook.**

*Ovary* syncarpous, superior, two-celled, each cell one-ovuled; ovule ventrally attached, amphitropous; micropyle superior.



*Fruit* baccate, ellipsoid, glabrous, black when mature or suffused with a glaucous bloom, two-celled, two-seeded.

*Seed* oval in outline, concavo-convex, peltate, ventrally attached to the middle of the placenta, pale, subtransparent and whitish; testa closely adhering to the endosperm; radicle superior and close to the micropyle; hilum large, oval, occupying the greater part of the concave ventral face.

*Endosperm* abundant, pale subtransparent white, fleshy and tough or subcartilaginous and easily cut, occupying the greater part of the seed.

*Embryo* straight, thin, falling a little short of the length of the seed, and slightly curved or concave towards its inner base, and conforming to its dorsal convexity; cotyledons thin, closely adpressed face to face, rotund-ovate, obtuse, entire, occupying a median position in the seed, a little nearer the dorsal than the ventral aspect, surrounded by endosperm; radicle very short, but the radicle and petioles together are about 3-4.5 mm. long, and nearly or quite equal to the cotyledons in length.

*Thevetia neriifolia*, Juss.

*Hypocotyl* 2-3 cm. long, 3 mm. thick, terete, glabrous, woody, colourless.

*Stem* woody, glabrous, light green; 1st internode 5-6 cm. long, 2-2.5 mm. thick; 2nd 1 cm. long; 3rd to 10th much shorter.

*Leaves* simple, entire, cauline, alternate or the earlier ones nearly or quite opposite, exstipulate, shortly petiolate or subsessile, decussating in the seedling stage, subcoriaceous, glabrous, bright green.

Nos. 1 and 2. Nearly opposite, subsessile, 3-5 cm. long, 6.5 mm. wide, linear-lanceolate, acuminate, with a distinct articulation at the base, entire, penninerved, straight or slightly recurved at the apex, channelled, quite glabrous, bright green, somewhat leathery.

Nos. 3-6. Nearly opposite, linear-lanceolate, acuminate; the rest alternate.

*Plumeria alba*, L. (fig. 514).

*Hypocotyl* woody, erect, terete, fleshy, glabrous, pale green, shining, ultimately becoming grey, about 2.8 cm. above the soil. Juice milky.

*Cotyledons* large, foliaceous, broadly oblong-cordate, obtuse, shortly petiolate, with the basal auricles frequently unequal; lamina

1·7 cm. long, 1·05 cm. wide ; petiole about 1 mm. long. Juice milky.

*Stem* woody, erect, terete, tapering upwards, glabrous, pale green becoming grey, fleshy, smooth or frequently warted, especially under the leaves ; 1st internode 1·5 cm. long ; 2nd 1·3 cm. ; 3rd 9 mm. ; 4th 1 cm. Juice milky.



FIG. 514.—*Plumeria alba*. Half nat. size.

*Leaves* simple, entire, cauline, alternate (1st and 2nd opposite), exstipulate, petiolate, glabrous, alternately pinninerved, deepgreen above, paler beneath, shining on both surfaces ; petioles convex on the back, flattened above or slightly channelled on each side of a prominent midrib, glabrous ; midrib of leaf prominent on both surfaces. Juice milky.

Nos. 1 and 2. Opposite, oblong-lanceolate, obtuse, minutely apiculate.

No. 3. Lanceolate, acute, tapering to both ends.

Nos. 4–6. Narrowly oblong, acute, tapering at the base.

***Tabernæmontana amygdalifolia*, Jacq.**

*Hypocotyl* erect, striated, scabrous, 5–6 cm. long, green.

*Cotyledons* broadly triangular or subcordate, obtuse, entire, somewhat wavy, petiolate, glabrous, green, distinctly pinnatinerved as are the leaves ; petioles comparatively short, furrowed on the upper face.

*Stem* erect, striated, scabrous, herbaceous, ultimately woody ; 1st internode about 3 cm. long ; 2nd about 5 mm.

*First leaves* simple, entire, cauline, opposite, decussate, broadly lanceolate or ovate, almost acuminate, obtuse, petiolate, exstipulate, glabrous, green, paler beneath, distinctly pinnatinerved ; petioles comparatively short, channelled on the upper face.

***Wrightia tinctoria*, R. Br.**

*Hypocotyl* erect, terete, glabrous, woody, 3·5–4 cm. long, brownish.

*Cotyledons* unequal, membranous, oblong, obtuse, entire, petiolate, glabrous, green, distinctly pinnatinerved like the leaves.

*Stem* erect, terete, herbaceous, ultimately woody; 1st internode 3·5 cm. long; 2nd about 8 cm.; 3rd rather shorter.

*First leaves* simple, entire, cauline, opposite, decussate, oblong-lanceolate, obtuse, petiolate, exstipulate, glabrous, green with a subglaucous hue above, pinnatinerved; petioles short, flat, slightly furrowed above.

***Parameria glandulifera*, Benth.**

*Hypocotyl* woody, terete, pubescent, 1·7 cm. long, 2 mm. thick, pale ashy grey.

*Cotyledons* shortly petiolate, ovate, obtuse, entire, coriaceous, pale green, 1·6–2·2 cm. long.

*Stem* erect, terete, thickened at the nodes, 2 mm. thick, and gradually tapering upwards, shortly, finely and densely pubescent; 1st internode 4–8 mm. long; 2nd 1·5 cm.; 3rd 1·8 cm. In different specimens these lengths are variable.

*Leaves* simple, entire, cauline, opposite, decussate, shortly petiolate, subacuminate, obtuse, coriaceous, penninerved, pale green, shining, finely pubescent on the midrib beneath; petiole 8 mm. long, flattened above and convex beneath, finely and densely pubescent, apparently connate at the base and surrounding the stem, forming a transverse scar with small black, stipuliform teeth on its upper edge.

First pair falling early, even before the cotyledons.

Second to fourth pairs lanceolate-elliptic, acuminate, obtuse, finely penninerved.

***Echites umbellata*, Jacq. (fig. 515).**

*Hypocotyl* erect, terete, slender, finely and minutely pubescent, about 8–10 mm. above the soil.

*Cotyledons* oblong, obtuse, entire, shortly petiolate, glabrous, coriaceous, alternately and ascendingly penninerved, with the nerves incurved and uniting at the tip, appearing somewhat reticulate, deep green above, with generally pinkish veins, paler beneath and often reddish, horizontal from ascending or suberect petioles; lamina 9·5–10·5 mm. long, 5–5·5 mm. wide; petiole semiterete, channelled above, slightly connate at the base, finely and minutely pubescent like the stem, dull purplish, about 1 mm. long.

*Stem* erect, terete, slender, almost filiform, ultimately woody and twining, finely and minutely pubescent when young, and purplish ; 1st internode 4-4.5 mm. long ; 2nd 1.45-1.6 cm.

*Leaves* simple, entire, cauline, opposite, decussate, exstipulate, shortly petiolate, alternately incurvinnerved and more or less reticulate, glabrous, coriaceous or subcoriaceous, deep green above, generally rather closely reticulated with red or pink, paler beneath and more or less suffused with pale red ; petioles very short, semiterete, shallowly channelled above, finely and minutely pubescent, and reddish like the stem.

First pair ovate, obtuse, slightly cordate at the base, or almost rounded.

Second pair ovate, more elongated and somewhat more pointed.



FIG. 515. → *Echites umbellata*.  
Nat. size.

#### ***Mandevilla suaveolens*, Lindl.**

*Primary root* fleshy, tapering, flexuose, colourless, and giving off lateral rootlets freely.

*Hypocotyl* erect or frequently flexuose, pale green, finely and minutely pubescent, 3-4.2 cm. long.

*Cotyledons* foliaceous, ovate, obtuse, alternately penninerved, reticulate, bright green and shining above, paler and shining beneath, finely pubescent on the petiole and midrib beneath and at the margin, otherwise glabrous ; lamina 2.2 cm. long, 1.2 cm. wide ; petiole erect, channelled above, 5 mm. long.

*Stem* erect and soft, ultimately twining and woody, minutely and closely pubescent, pale green ; 1st internode 1.8 cm. long.

*Leaves* simple, entire, cauline, opposite, exstipulate, petiolate, minutely and finely pubescent on the petioles, the under sides of the midrib especially at the forkings of the veins and at the base of the leaf and at the margins, otherwise glabrous, alternately penninerved with ascending nerves slightly incurving at the tip, reticulate ; petioles semiterete, shallowly channelled above, ultimately glabrous except in the channel, green or deeply stained with crimson.

First pair lanceolate, acute.

Second and probably the third pairs similar.

Ultimate leaves oblong-cordate, acuminate, acute.

## ASCLEPIADEÆ.

Benth. et Hook. *Gen. Pl.* ii. 728.

*Fruit and Seed.*—The ovary is superior and consists of two distinct carpels, with their placentas on the ventral suture. The stigmas are however confluent into one. The ovules are numerous in each carpel, arranged in many series and imbricated, the uppermost being outermost, pendulous, anatropous, from a slightly prominent placenta. The fruit consists of two erect or widely spreading follicles, or one of them may be aborted, sessile, oblong, ovoid, or elongated, or fusiform, smooth, muricate, or many-winged, dehiscing by the ventral suture, often breaking away from the placentas. The seed is ovate, oval, oblong or elliptic, dorsally much compressed and often surrounded with a thin margin. The testa is membranous or coriaceous and often crowned with a long silky tuft of hairs as occurs in Apocynaceæ. Endosperm is present, usually copious and cartilaginous. The embryo is straight and axile, nearly equalling the endosperm in length with broad flat cotyledons and a short superior radicle. An exception to the above characters occurs in *Atherandra* where the ovary is half inferior. The terminal pencil of hairs is absent from the seeds of *Finlaysonia* and *Sarcolobus* (tropical Asia) and of *Gonolobus stenopetalus* (Mexico).<sup>1</sup>

The embryo of *Periploca lævigata* nearly equals the endosperm in length and has foliaceous, broadly oblong cotyledons. Several seeds examined contained two embryos. The seeds are surmounted by a coma which falls early. The same may be said of *Stephanotis floribunda*, the comose tuft of hairs of which is long, white and silky. The object of the coma is evidently for the distribution of the seed, but the thin and almost winged character of the latter renders the coma of less importance than it otherwise would be. The fruit consists of two very large fleshy follicles with exceedingly numerous seeds. The cotyledons are suborbicular.

<sup>1</sup> A. Gray, *Proc. Amer. Acad.* xxi. 398.

*Seedlings*.—Oblong and ovate cotyledons predominate in this Order, but oval and subrotund ones are also met with. Those of *Calotropis gigantea* (fig. 518) are broadly oblong, obtuse, and entire, with an incurved venation similar to that of the first pair of leaves which are more elliptic in outline. *Asclepias obtusifolia*, *Tylophora asthmatica*, and *Gymnolæma viride* agree pretty closely with this type in having oblong, obtuse cotyledons with a venation resembling that of the primary leaves; they vary somewhat in width, but are always wider than the first pair of leaves. The first pair in *Tylophora asthmatica* are oblong-lanceolate, while the first five pairs of *Gymnolæma viride* are narrowly lanceolate and acute, or even acuminate. The cotyledons of *Schubertia grandiflora* are shortly oblong, obtuse, and of the same width as the ovate first pair of leaves.

A slightly different type of seedling is met with in *Gomphocarpus campanulatus* (fig. 517), which by its slender stems and long internodes shows a tendency to climb. The cotyledons are oblong with an incurved venation like that of the first three pairs of leaves which are ovate or subcordate and hairy. The cotyledons of a species of *Microlooma* (fig. 516) are also oblong with incurved nerves, but they are notable for the great length of their petioles. The latter characteristic is due to the unusual shortening of the hypocotyl and probably to the nature of the situation in which the plant grows, necessitating the lengthening of the petioles in order to bring the lamina up to the light. The two first pairs of leaves are small and scale-like, while the succeeding three are linear-lanceolate with a few alternate, ascending, indistinct nerves on each side of the more evident midrib.

The ovate type of cotyledons is represented by *Periploca lævigata* where they are broader than the primary leaves with a similar venation. The first three pairs of leaves are ovate-elliptic. Some succulent types of seedlings have ovate cotyledons broader and larger than the leaves that follow them. Those of *Sarcostemma brevistigma* (fig. 519) are oblong-ovate and sessile. The first two pairs of leaves are ovate, but they are reduced to minute, scale-like organs. This plant like the species of *Stapelia* is notable for the stout

fleshy character of the hypocotyl in its early stages. The seeds of *Stapelia bufonia* germinated in the remarkably short space of three or four days. The cotyledons are small, ovate, plano-convex, and after germination assume an ascending direction, placed obliquely to the axis or slightly twisted with the faces of the two turned in different directions. Those of *Stapelia mutabilis* and *S. variegata* (fig. 522) are similar and behave in the same way. The primary leaves of *S. mutabilis* are very small, conical, acute, opposite, decussate, very numerous on the short stem, and decurrent at the base, forming angles on the stem. The hypocotyl of *S. variegata* is remarkably large, clavate, fleshy, and compressed in a different plane from that of the cotyledons. The leaves are more shortly conical even than those of *S. mutabilis*, but are otherwise similar. The internodes of the young stem are slightly more elongated. Seedlings raised from seeds sent from Bangalore under the name of *Hoya viridiflora* (fig. 520) had broadly oval cotyledons with an incurved venation, and rather more numerous veins than in the first five pairs of leaves which are elliptic. Roundly oblong and emarginate cotyledons are met with in *Stephanotis longiflora*. The two first pairs of leaves are small and elliptic, followed by three pairs that differ only in being much larger. The cotyledons of a species of *Ceropegia* (fig. 521) from South Africa are roundly triangular and truncate at the base. The first four pairs of leaves vary from oblong to elliptic and are wavy at the margin.

***Gymnolæma viride*, Benth.**

*Hypocotyl* erect, terete, glabrous, 1-1·7 cm. long, light green.

*Cotyledons* oblong, obtuse, entire, shortly petiolate, glabrous, dull green, pinnatinerved like the leaves; the nerves are raised on the upper side, giving them a wrinkled appearance.

*Stem* erect, terete, herbaceous, green, glabrous; 1st internode 8-13 mm. long; 2nd and 3rd 1·2-1·8 cm.

*First leaves* simple, entire, cauline, opposite, decussate, shortly petiolate, linear-lanceolate, acute, glabrous, light green, pinnatinerved, clothed with short silky hairs when young.

***Periploca lævigata*, Ait.**

*Seed* triangular or plano-convex, obovate, considerably laterally

flattened, about 5–6 mm. long; testa membranous, smooth, brownish, slightly winged at the edges and thickened near the hilum, comose; hilum rather conspicuous.

*Endosperm* surrounding the embryo, whitish-grey, and rather copious.

*Embryo* straight, embedded in the endosperm, yellowish-white; cotyledons broadly oblong, obtuse, entire, sessile, plano-convex, lying face to face in the broad way of the seed with their edges to the axis; radicle considerably shorter than the cotyledons. In two out of three seeds there were two embryos, the cotyledons lying obliquely in the broad way of the seed.

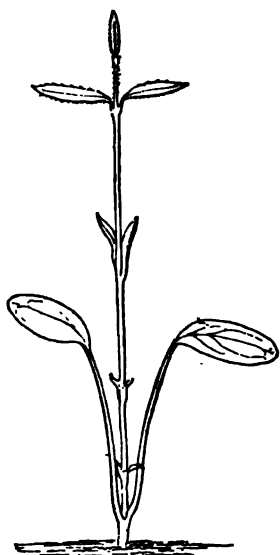


FIG. 516.—*Microloma* sp.  
One-third over nat. size.

### Seedling.

*Hypocotyl* erect, terete, covered with minute hairs, 1–2.5 cm. long, brownish-green.

*Cotyledons* ovate, subacute, entire, shortly petiolate, covered with minute hairs, dark green, pinnatinerved like the leaves.

*Stem* erect, terete, herbaceous, ultimately woody, covered with minute hairs; 1st internode 1–1.5 cm. long; 2nd 1–1.2 cm.

*First leaves* simple, entire, cauline, opposite, decussate, ovate-elliptic, acute, shortly petiolate, exstipulate, ciliate, covered with minute hairs, dark green, pinnatinerved.

### *Microloma* sp. (fig. 516).

*Hypocotyl* erect, terete, very short, almost colourless.

*Cotyledons* oblong, obtuse, with long petioles, glabrous with a few alternate, ascending nerves, two of the larger of which curve round or inwards to the midrib near the apex, deep green; lamina 9–10 mm. long, 8.5–4 mm. wide; petiole semiterete, slender, slightly channelled above, about 1.85 cm. long.

*Stem* erect, terete, pale green, pubescent, ultimately twining and subshrubby; 1st internode 5 mm. long; 2nd 8.5 mm.; 3rd 1.1 cm.; 4th 1.6 cm.

*Leaves* simple, entire cauline opposite, exstipulate, with short



petioles, alternately and ascendingly penninerved, thinly hairy (at least when young); petioles very short, thinly hairy, semiterete, slightly channelled above.

First and second pairs very small, almost scale-like, but green, lanceolate, obtuse.

Third and fourth pairs much larger, but still narrower than the cotyledons, linear-lanceolate, acute, with a few alternate, ascending nerves.

*Schubertia grandiflora*, Mart. et Zucc.

*Hypocotyl* erect, terete, hoary, about 2 cm. long, light green or colourless.

*Cotyledons* entire, broadly ovate or oval, obtuse, dark green above, subglaucous beneath, petiolate with petioles 1 cm. long, glabrous, but the petioles slightly hoary, 1.5 cm. long, 1.25 mm. wide, with a prominent midrib from which ascend numerous veinlets; the venation is the same as in the primary leaves.

*Stem* herbaceous, erect, terete, slightly pubescent, pale green; 1st internode 1 cm. long; 2nd much shorter.

*Leaves* entire, cauline, simple, exstipulate, petiolate, ovate, acute, dark green above, lighter beneath, glabrous with minute hairs on the edges; midrib with numerous ascending veinlets.

*Gomphocarpus campanulatus*, Harv. (fig. 517).

*Hypocotyl* erect, terete, glabrous, pale green (herbaceous when sketched), 8-8 mm. above the soil.

*Cotyledons* oblong, obtuse, petiolate, glabrous, deep green above, shining; lamina 11 mm. long, 6.5 mm. wide; petiole glabrous, grooved above, convex on the back, 6.5 mm. long.

*Stem* herbaceous at least in the early stages, erect, terete, ultimately twining, hairy with patent hairs, pale green or suffused with pale purple; 1st and 2nd internodes each 5 cm. long.

*Leaves* simple, entire, cauline, opposite, exstipulate, petiolate, hairy on both surfaces, dull green above and dotted with the swollen bases of the hairs, pale green and shining beneath; petioles very short, semiterete, channelled on the upper side, hairy.

First three pairs small, ovate-subcordate, obtuse.

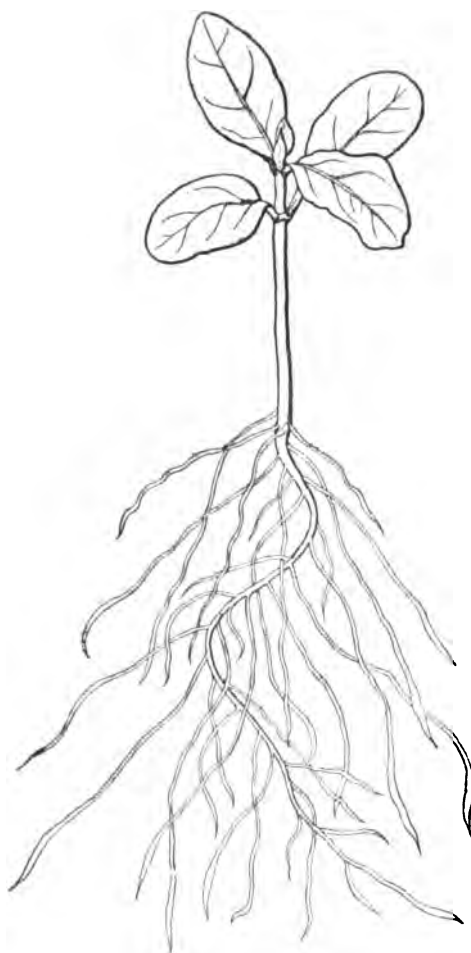


FIG. 517.  
*Gomphocarpus*  
*campanulatus*.  
Half nat. size.

***Calotropis gigantea*, R. Br. (fig. 518).**

*Primary root* long, flexuose, somewhat woody, with long, unbranched colourless fibres.

*Hypocotyl* firm, 8 cm. long, 1-2 mm. thick, terete, glabrous and whitish near the base, slightly tomentose, and bluish-brown above.



*Cotyledons* shortly petiolate, oblong, produced at the base and forming a channel on the petiole, rounded at the apex, entire, penninerved, glabrous, dull yellowish-green above, slightly paler and shining beneath, not very thick; petiole semiterete, channelled above, connate at the base.

*Stem* woody; 1st internode about 6 mm. long, slightly compressed, green, tomentose.

*Leaves* simple, entire, cauline, opposite, exstipulate, shortly petiolate, alternately incurvinnerved, tomentose, greyish or hoary, subcoriaceous.

First pair elliptic, obtuse, entire, penni-

FIG. 518.—*Calotropis gigantea*. Nat. size

nerved, subsessile, 2-2.5 cm. long, and 1-1.25 cm. wide, not very thick, slightly tomentose, dull greyish-green, slightly paler and shining beneath.

***Asclepias obtusifolia*, Michx.**

*Hypocotyl* erect, terete, glabrous, 2·5–4·5 cm. long, light green tinged with red.

*Cotyledons* broadly oblong, obtuse, entire, petiolate, glabrous, green, pinnatinerved as in the leaves.

*Stem* erect, terete, herbaceous, covered with minute hairs; 1st internode 1–1·2 cm. long.

*First leaves* simple, entire, cauline, opposite, oblong, obtuse, shortly petiolate or subsessile, exstipulate, covered with minute hairs, light green, pinnatinerved.

***Sarcostemma brevistigma*, Wight et Arn. (fig. 519).**

*Hypocotyl* erect, thickening upwards, glabrous or with a few scattered hairs, glaucous-green and dotted all over with very minute colourless markings, 2–2·5 cm. long.

*Cotyledons* oblong-ovate, obtuse, entire, subfleshy, glabrous, deep shining green above, paler beneath, with an indistinct midrib, sessile, 5–5·5 mm. long, 2·5–2·75 mm. wide, caducous.

*Stem* erect in the seedling stage, terete, slightly downy, glaucous-green, dotted with minute colourless markings, ultimately shrubby, scandent or procumbent; 1st internode 1·8–2 cm. long; 2nd 1·2–1·7 cm.

*Leaves* simple, entire, cauline, opposite, decussate, exstipulate, sessile, all reduced to ovate or subulate, acuminate scales so small as to give the stems a leafless appearance.

Nos. 1 and 2. Ovate, minute, with an acute or acuminate, slender tip, pale green, slightly downy with a brown tip.

***Stephanotis floribunda*, A. Brongn.**

*Fruit* very thick, fleshy, oblong, obtuse, many-seeded, consisting of one to two follicles.

*Seed* much compressed dorso-ventrally, flat, winged, comose, oblong-obovate, retuse at the base where the coma is attached, this consists of exceedingly numerous, long, white, silky hairs; hilum minute on the base of the ventral aspect; raphe ventral and passing

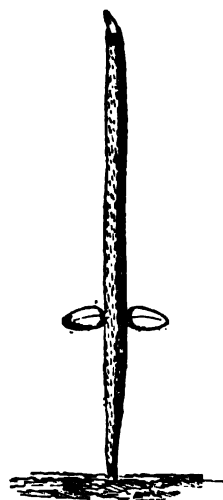


FIG. 519.—*Sarcostemma brevistigma*. Nat. size.

along more than half the length of the seed ; micropyle superior ; wing narrow.

*Endosperm* copious and fleshy, surrounding the embryo.

*Embryo* straight, flat, large, colourless, nearly as long as the endosperm ; cotyledons flat, broadly oval or suborbicular, central, entire ; radicle cylindrical, obtuse, about one-half to two-thirds as long as cotyledons, close to the apex of the endosperm, pointing to, but some little distance from the hilum.

***Stephanotis longiflora*, ? Hort.**

*Hypocotyl* woody, erect, terete, finely pubescent, pale green, about 7–10 mm. above the soil.

*Cotyledons* foliaceous, rotund-oblong, emarginate, rigid, coriaceous, glabrous, shortly petiolate, pale green and shining above, paler beneath ; lamina 1.1 cm. long, 1 cm. wide ; petiole slightly grooved above, 1 mm. long.

*Stem* woody, erect in the seedling stage, terete or slightly flattened in the opposite way to the leaves, finely pubescent, shining, green or subglaucous-green ; 1st internode 4.5 mm. long ; 2nd 4.25 mm. ; 3rd 1.5 cm. ; 4th 1.95 cm. ; 5th 3.65 cm.

*Leaves* simple, entire, cauline, opposite, decussate, exstipulate, petiolate, glabrous, thick, rigid or coriaceous, alternately and obscurely penninerved, even and shining on both surfaces, with the midrib slightly prominent beneath, and a pale hyaline or pink cartilaginous margin ; petioles short, stout, slightly grooved above, rounded on the back and thickened at the base.

First pair elliptic, obtuse.

Second pair larger, subacute.

Third pair much larger, elliptic, acute.

Fourth pair small, unequal in size, acute.

Fifth pair large, elliptic, acute.

***Hoya viridiflora*, R. Br. ? (fig. 520).**

*Hypocotyl* erect, terete, glabrous, pale green, 6–12 mm. above the soil.

*Cotyledons* foliaceous, broadly oblong or oval, rounded at the apex, tapered to the base, petiolate, alternately and ascendingly penninerved with the tips only incurved and uniting with those next above them, shortly pubescent on the midrib above, otherwise glabrous, thin and membranous, light green above, and marked with pale-coloured dots ; lamina about 1.8 cm. long, 1.2 cm. wide ; petiole grooved above, convex on the back, dilating upwards, 6.5–7 mm. long.

*Stem* erect, terete, pubescent with curved hairs, pale green, soon becoming almost colourless, ultimately climbing; 1st internode 3.5–3.8 cm. long; 2nd 2–2.4 cm.; 3rd 1.8–2.2 cm.

*Leaves* simple, entire, cauline, opposite, decussate, stipulate, petiolate, alternately and ascendingly incurvinerved with the principal nerves giving off numerous anastomosing branches, thin and subcoriaceous in the seedling stage, thinly pubescent on the nerves on both surfaces with curved hairs, but denser towards and on the margin, deep green above, paler beneath; petiole semiterete, channelled above, pubescent on the edges and back with curved hairs; stipules minute, glandular, subulate, soon becoming brown and scarious, deciduous.

First to fifth pairs elliptic, obtuse, the upper ones shortly acuminate and more elongated or tapered to each end.



FIG. 520.—*Hoya viridiflora*.  
Half nat. size.

**Ceropegia sp. (fig. 521).**

*Hypocotyl* succulent, scarcely 1 cm. above ground, 3–4 mm. thick, slightly compressed, glabrous, pale green.

*Cotyledons* subsessile, nearly equal, about 1 cm. long and wide, and 1–2 mm. thick, roundly triangular or almost orbicular, with a truncate base and very obtuse apex, entire, nearly flat, marginate, obscurely nerved, succulent, glabrous, glossy green.

*Stem* succulent, suberect, terete, half as thick as the hypocotyl in the young stage, minutely verrucose, dark green.

*Leaves* simple, entire, cauline, opposite, decussate, exstipulate, very shortly petiolate or subsessile, succulent, glabrous, with a midrib but an otherwise indistinct venation, green more or less suffused with a purplish tint.

First pair oblong, cuneate at the base, obtuse, glabrous with a

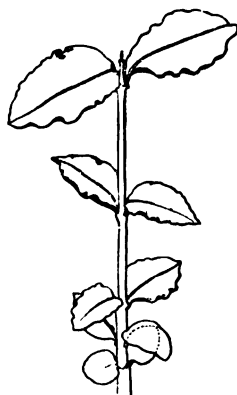


FIG. 521.—*Ceropegia* sp.  
Half nat. size.

sunk midrib, shortly petiolate, about 2 cm. long, and 1.5 cm. wide, succulent, purplish on both surfaces.

Second pair ovate, acuminate, with short, broad petioles, differing also from the first in the undulated margin and the silvery nerves and veins.

Third and subsequent pairs more lanceolate-ovate and much larger; fourth pair about 3.5 cm. long and 1.5 cm. wide.

***Stapelia variegata*, L. (fig. 522).**

*Hypocotyl* erect, clavate, succulent, compressed the opposite way to the cotyledons, glabrous, pale subglaucous-green, 1.7 cm. above the soil.



FIG. 522.  
*Stapelia variegata*.  
Nat. size.

*Cotyledons* ovate, obtuse, twisted obliquely and each facing an opposite way, ascending, coloured like the petiole, 3.5 mm. long, 2.5 mm. wide, sessile, persistent.

*Stem* succulent, erect, obtusely quadrangular by the decurrent bases of the leaves, glabrous, coloured like the hypocotyl; 1st internode 6 mm. long; 2nd 4 mm.; 3rd 3.5 mm.

*Leaves* succulent, simple, entire, small, cauline, opposite, decussate, exstipulate, sessile, coloured like the stem, shortly conical, acute, decurrent at the base, forming angles on the stem, horizontal, 1.5–1.75 mm. long.

***Stapelia bufonia*, Jacq.**

*Seeds* ovate or oval in outline, surrounded by a corky rim, germinating in three or four days.

*Primary root* tapering, abundantly covered with root-hairs, colourless, rather stout.

*Hypocotyl* as in *S. variegata*, 2.05 cm. long, 3 mm. wide on the flattened faces, and 2 mm. on the narrow.

*Cotyledons* ovate, obtuse, sessile, plano-convex, and applied to each other obliquely in the seed by their flattened faces, which afterwards remain in an oblique position, each facing a different direction, 3 mm. long, 1.5 mm. wide, persistent.

***Stapelia mutabilis*, Jacq.**

*Hypocotyl* as in *S. variegata*, 1.15 cm. above the soil.

*Cotyledons* as in *S. bufonia*, horizontal or placed obliquely, each facing a different way, pale subglaucous-green faintly mottled with paler markings, 2 mm. long, 1.25 mm. wide.

*Stem* as in *S. variegata*, pale glaucous-green mottled with

minute paler markings; 1st internode 4 mm. long; 2nd to 8th inclusive each about 2-2.5 mm.

*Leaves* as in *S. variegata*, but longer and more acute, and tipped with a cartilaginous point; 2.5 mm. long.

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## GENTIANEÆ.

Benth. et Hook. *Gen. Pl.* ii. 799.

*Fruit and Seed.*—The ovary is superior, syncarpous, consisting of two carpels generally uniting by their edges so as to form one cell, with two parietal single or double placentas which are slender or prominent and project into the cavity; sometimes the margins of the carpels project into the centre of the ovary, forming two cells with axile placentas, as in the tribe Exacææ. The ovules are generally numerous in each cavity or on each placenta, and arranged in one or more series, anatropous or amphitropous. The fruit is a thin or hard, rarely a fleshy capsule, dehiscent in most cases by two valves at the sutures, rarely bursting irregularly. Sometimes the whole inner surface is placentiferous. The seed is globose or angled, rarely compressed. The testa is membranous or crustaceous, smooth or rugose, and sometimes produced into a marginal wing all round, or at the base and apex only. Endosperm is copious, surrounding a small and short embryo, the radicle of which is superior or points in various directions according to the species.

*Seedlings.*—The most common form of the cotyledons in this Order is ovate, and they are small like the seeds. In *Exacum bicolor* (fig. 523), which may be given as a type, they are roundly ovate, petiolate, 3 mm. long and the same in width. The first pair of leaves is lanceolate-elliptic and trinerved, followed by two other pairs which are very much larger, with longer lateral nerves, but otherwise similar. The cotyledons of *E. macranthum* are broadly and roundly ovate, one-nerved, 3-5 mm. long, and 2-4 mm. wide. The first two pairs of leaves are broadly ovate, obtuse, and trinerved with the lateral ones incurved and joining the midrib close to

the apex. The same type of cotyledon is seen in *Gentiana verna* (fig. 525), but the lamina is cuneate at the base and tapers into the petiole, which unites with its fellow and forms a little cup round the axis. The first five pairs of leaves are precisely like the cotyledons except in being slightly larger. In each case a midrib is the only apparent venation. The cotyledons of *Swertia corymbosa* are small, triangular-ovate and subtruncate at the base. Those of *Erythræa pulchella* are oblong-ovate and very small.

The seedling of *Orphium frutescens* (fig. 524) is remarkably distinct from any of the above. The cotyledons are shortly linear, without any apparent venation. The first five pairs of leaves are linear-spathulate and one-nerved, increasing in size from the first onwards. The primary internodes of the stem, which ultimately becomes shrubby, are elongated.

***Exacum bicolor*, Roxb. (fig. 523).**

*Hypocotyl* erect, terete, glabrous, pale green, 1-8 mm. above the soil.

*Cotyledons* rotund-ovate, obtuse, petiolate, glabrous; lamina 8 mm. long, 8 mm. wide at the base; petiole channelled above, 1.5 mm. long.



FIG. 523.—*Exacum bicolor*. Nat. size.

*Stem* herbaceous, elongated when about to flower, glabrous, two-edged, pale green; 1st internode undeveloped; 2nd and 3rd each about 1.5 mm. long.

*Leaves* simple, entire, radical and cauline, opposite, exstipulate, petiolate, glabrous, shining on both surfaces, deep green above, paler

beneath; petioles convex on the back, channelled on the upper side.

First pair small, lanceolate-elliptic, obtuse, trinerved at the base, tapering into the petiole.

Second and third pairs elliptic, obtuse, trinerved, tapering into the petiole.

***Exacum macranthum*, Arn.**

*Hypocotyl* colourless, 2-8 mm. long, with a slight ridge.

*Cotyledons* very similar to those of *E. bicolor*.



*Stem* slightly ribbed ; internodes of the seedling mostly of the same length, from 8–10 mm. long.

*Primary leaves* cauline, opposite, decussate, obtusely ovate, shining, green, trinerved, with a midrib and two lateral nerves parallel to the edges, and meeting at the apex.

***Orphium frutescens*, E. Mey. (fig. 524).**

*Hypocotyl* erect, terete, glabrous, pale green, 4–11 mm. long.

*Cotyledons* shortly linear, obtuse, flattened above, convex on the back, sessile and slightly connate at the base, glabrous, deep green, shining when young, 5–6 mm. long, 1–1·25 mm. wide, frequently carrying up the seed on their tips during germination.

*Stem* erect, terete, light green when young, thinly pubescent, with a shallow furrow on alternate sides from where the edges of the leaves unite at their bases and seem to be decurrent on the stem down to the next node, ultimately shrubby ; 1st internode 4–6·5 mm. long ; 2nd 5–10·5 mm. ; 3rd 1·8–2 cm.

*Leaves* simple, entire, cauline, opposite, decussate, exstipulate, sessile, with an evident midrib but no other discernible venation, fleshy, deep shining green in the young state, thinly pubescent and densely marked all over with minute pale grey or colourless dots, tomentoso-pubescent or glabrous in the adult state, spreading, often curving upwards above the middle, and sometimes slightly twisted.

First pair linear-spathulate, suddenly tapered to a subacute tip.

Second to fifth pairs linear-spathulate, gradually longer, more obtuse, and the uppermost more decidedly linear, gradually tapering to a subclasping and very shortly connate base.

Ultimate leaves linear or oblong, thick and rather fleshy.

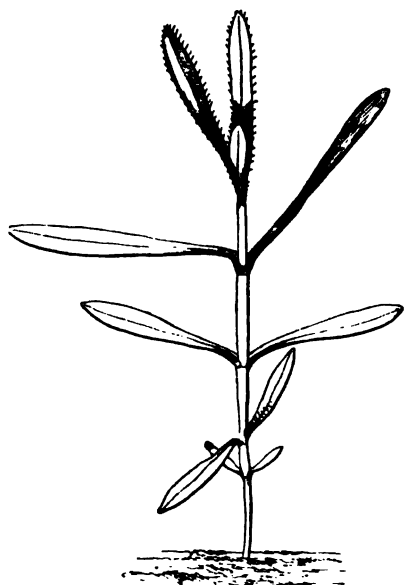


FIG. 524.—*Orphium frutescens*. Nat. size.

***Erythraea pulchella*, Fr.**

*Primary root* short, fibrous, branched.

*Hypocotyl* erect, terete, glabrous, short and tapering indistinguishably into the radicle.

*Cotyledons* oblong-ovate, obtuse, entire, shortly petiolate, glabrous, very small, 1.5–2 mm. long including the petiole, and 1–1.25 mm. wide.

*Stem* herbaceous, angled, ridged and furrowed, glabrous; 1st and 2nd internodes undeveloped; 3rd 5–7 mm. long.

*Leaves* simple, entire, radical and cauline, opposite-decussate, exstipulate, sessile or the first pair shortly petiolate, glabrous, longitudinally nerved.

First pair spatulate, obtuse, shortly petiolate, one-nerved.

Second pair oblong-elliptic, trinerved, sessile.

Third pair obovate-oblong, trinerved, sessile.

***Gentiana verna*, L. (fig. 525).**

*Primary root* slender, fibrous, perennial.

*Hypocotyl* erect or decumbent, terete, filiform, deep purplish-red, glabrous, 6–9 mm. long.

*Cotyledons* ovate, obtuse, entire, petiolate, showing a midrib but no other venation in a fresh state, glabrous, deep green, somewhat shining; lamina 1.75–2.25 mm. long, 1.5–1.75 mm. wide; petiole flattened above, convex on the back, green or with a red midrib, glabrous, connate at the base, about 1 mm. long.

*Stem* herbaceous, procumbent or creeping, and with ascending flowering shoots, terete, glabrous, pale green or reddish; 1st internode 2–4.5 mm. long; 2nd undeveloped or from .5–2 mm.

*Leaves* simple, entire, cauline, opposite, exstipulate, petiolate, glabrous, deep green above, paler beneath, trinerved at least in the seedling, with the lateral nerves incurved and uniting with the midrib at the

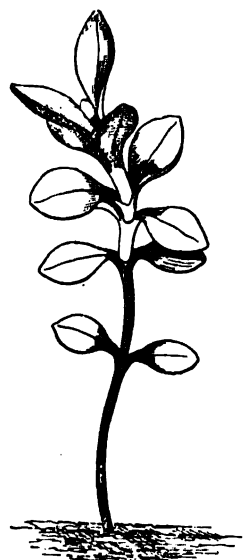


FIG. 525.  
*Gentiana verna*, x 8.

apex; petiole convex on the back, channelled above, connate and clasping at the base.

First to fifth pairs small, ovate, obtuse or, by tapering into the broadish petiole, subelliptic.

***Swertia corymbosa*, Wight.**

*Hypocotyl* scarcely appearing above the soil.

*Cotyledons* triangular-ovate, obtuse, entire, subtruncate at the base, petiolate, glabrous, green, one-nerved; petioles short, flat, shallowly channelled above.

*Stem* erect, square, glabrous, herbaceous; 1st and 2nd (sometimes 3rd, 4th, 5th, and 6th) internodes undeveloped, later ones considerably elongated.

*Leaves* simple, entire, cauline or radical, decussate, exstipulate; radical ones on rather long petioles, the cauline, sessile; oval-oblong, obtuse, glabrous, green, trinerved; petioles flat, considerably channelled on the upper face.

First and second pairs ovate-elliptic.

Third to fifth pairs broadly oval.

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**POLEMONIACEÆ.**

Benth. et Hook. *Gen. Pl.* ii. 820.

*Fruit and Seed.*—The ovary is superior and consists of three carpels united to form three cells with axile placentas; but a dimerous ovary occurs in some species of *Collomia* and other genera. There are two or more ovules in each cell, but they are rarely numerous, inserted by the middle on axile placentas and amphitropous. The fruit is capsular and dehisces loculicidally, rarely septicidally as in *Cobæa scandens* and other species of that genus. In these the placentas are flat and of great width and thickness; but in other cases the valves burst away carrying more or less of the septa and placentas on their middle. The seeds are ovoid, angled or dorsally flattened. The testa is sometimes developed into a wing at the margin, or in other cases covered with mucilage sometimes growing out into spiral tubes. The endosperm is copious and fleshy, or thick and cartilaginous or reduced to a very thin layer. The embryo is straight and axile, rarely one half shorter than the endosperm, with flat and generally rather broad cotyledons, and a short inferior radicle.

The three cells of the ovary of *Collomia coccinea* contain but a single ovule each, although other species have numerous

ovules. The seeds are oblong, solitary and erect from the base of the inner angle of each cavity. The embryo occupies the greater part of the seed, and has thick, oval, plano-convex cotyledons and a well-developed radicle. *Gilia laciniata* is somewhat similar, but the seeds are very much smaller and the embryo relatively narrower with narrowly oblong, plano-convex cotyledons, considerably longer than the radicle. The ovules of *Polemonium cæruleum* are numerous, pendulous, and anatropous. The seeds are oblong and rather acutely trigonous by mutual pressure. The embryo almost equals the seed in length, but it is relatively very narrow, with linear-oblong cotyledons about the same length as the radicle. The ovules of *Cobæa scandens* are very numerous and arranged in a double series on each side of the middle line of the placental axis which is flattened with the placentas separated from one another but by no means prominent. The seeds (fig. 529) are the largest and most distinct of the Order observed; but they are exceptional rather than characteristic of the Polemoniaceæ. The fruit is a very large oblong capsule of three to four carpels with six to eight single placentas formed by separation of two that are usually united into one in other Orders. The seeds are large, oval or elliptic, much compressed dorsally, and nearly filled by a large embryo. The cotyledons are ovate-cordate, foliaceous and flat, with numerous incurved veins; and the terete radicle is very short.

*Seedlings*.—The cotyledons in this Order are all of simple types, and as a rule moderate in size. They vary from ovate to oval, spathulate and linear. In *Polemonium cæruleum* they are oblong-ovate. The first leaf is pinnate and trifoliate; the second and third five-foliate. The cotyledons of *Collomia coccinea* (fig. 526) are broadly ovate-oblong, generally minutely emarginate, with numerous alternate, ascending, incurved nerves, uniting in a submarginal line. The first pair of leaves are lanceolate-elliptic and entire; the second similar or with one to two teeth on each side. *Cobæa scandens* is very exceptional in the Order. The seeds are unusually large and so is the seedling. The cotyledons are large, foliaceous and ovate, subacute with a prominent midrib and primary lateral nerves. The first pair of leaves are

opposite and imparipinnate with three pairs and an odd leaflet, all of which are oblong-lanceolate and penninerved. The second pair of leaves are opposite or slightly alternate, paripinnate and ending in a compound alternately branching tendril. They have each three pairs of leaflets. The fifth and sixth leaves are similar but alternate.

The seedling of *Navarettia involucrata* closely resembles that of *Polemonium cæruleum*, but the cotyledons are more oval, the first two leaves are quinquefoliate, and the hypocotyl is more elongated.

The cotyledons of *Gilia crassifolia* (fig. 527) are spatulate with rather long petioles, dilated and connate at the base. The primary internodes being undeveloped a large number of the leaves are radical, and exhibit a considerable amount of evolution. The first pair are pinnatisect with five segments; the second pair have eleven to thirteen segments, and from the third pair onwards many of the primary ones are again divided at the base, making the leaves bipinnatisect. In *Gilia lutea* (fig. 528) belonging to the subsection *Leptosiphon*, the cotyledons are also spatulate but very small. The leaves also show a very distinct character in being palmately divided into linear segments, and being opposite they present a verticillate appearance. The first and second pairs are tripartite; the third pair have five segments, and the ultimate leaves are cut into seven to eleven linear diverging rays.

In *Gilia squarrosa* we have a seedling resembling that of *G. crassifolia* in habit, with a somewhat similar evolution of the leaves. The cotyledons are short and linear, and the first pair of leaves are like them but longer. The second pair have five segments; the third pair have five to seven segments; and the fourth pair are somewhat bipinnatisect with linear segments.

***Collomia coccinea*, Lehm.**

*Ovary* of three carpels, surrounded at the base with a small annular disk, three-celled, with one ovule in each cell; ovule basal from the inner angle of the cell, erect, anatropous; micropyle inferior.

*Fruit* an obovoid-trigonus or trilobed capsule, glabrous, pale green, ultimately pale, colourless or dirty white, thin, brittle when

dry, three-celled, three-seeded, dehiscing loculicidally, and also separating from the septa in three pieces, giving them the appearance of valves bearing the septa along their middle.

*Seeds* oblong, slightly compressed on the ventral aspect, solitary in each cell, erect, pale green, ultimately brown and slightly uneven; raphe ventral, somewhat shorter than the seed; hilum small, basal or slightly above the base on the ventral aspect; radicle at the extreme base, forming a slight prominence; testa consisting of somewhat pulpy adhesive matter when young, firm, brown and fibrous when mature.

*Endosperm* scanty, fleshy, colourless or nearly transparent.

*Embryo* always straight in the axis of the fleshy endosperm, comparatively large and occupying the greater part of the interior of the seed and nearly as long, deep green, pale yellow when mature; cotyledons closely applied face to face, plano-convex, oblong or oval, obtuse, entire; radicle well developed.

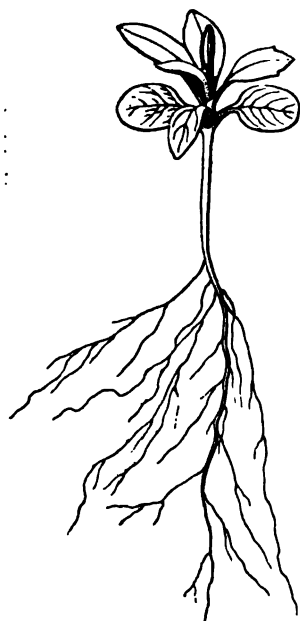


FIG. 526.—*Collomia coccinea*.  
Nat. size.

#### Seedling (fig. 526).

*Primary root* long, tapering, with numerous lateral, flexuose fibres.

*Hypocotyl* erect, tapering downwards, pubescent, white beneath the soil, brown above, 6-14 mm. long.

*Cotyledons* oblong, obtuse, minutely emarginate, very slightly wider at the base, with a distinct midrib terminating in a water-gland, a colourless, cuneate mass of tissue sunk in the apex of the cotyledon and even with its surface. The midrib has many lateral, alternate, ascending nerves incurving towards their tip and uniting each with the next one above it, giving the appearance of two intramarginal nerves, and end finally like the midrib just beneath the water-gland. Tertiary nerves are given off along the anterior side of the secondary nerves and unite with the secondary nerve immediately above them. All this forms a perfectly continuous framework throughout the cotyledon, and in direct communication with the water-gland.

Around the apex of the leaf are numerous water-pores, seen

from the upper surface, but better from beneath. A few are found a little way below the apex, but not so many nor so conspicuous as in *Galium Aparine*. The tissue immediately beneath the apex consists of polygonal cells with numerous small chlorophyll granules arranged round their sides, covered with wavy-outlined epidermal cells. The epidermal cells on the rest of the cotyledon are larger and very wavy, while the chlorophyll granules immediately beneath are very large and globose-ovoid, glabrous, deep opaque green above, paler beneath, subfleshy; lamina 8–10 mm. long, 6·5–7·5 mm. wide; petiole channelled above, glandular-pubescent, subperfoliate at the base, 4–5 mm. long.

*Stem* annual, branched, elongated when about to flower; primary internodes undeveloped.

*Leaves* simple, radical and cauline, alternate (lower ones opposite), exstipulate, petiolate, obscurely and alternately incurvinerved with the nerves uniting close to the margin, glandular-pubescent on both sides, deep opaque green above, paler beneath; petioles short, broad, channelled above, dilated at the base and subperfoliate in the opposite leaves.

First pair lanceolate-elliptic, entire, mucronate, obtuse.

Second pair lanceolate, subacute, mucronate, entire or having one to two teeth on each side.

*Gilia crassifolia*,  
*Benth.* (fig. 527).

*Primary root* long, slender, tapering, with numerous lateral rootlets, annual.

*Hypocotyl* tapering downwards, colourless, subterranean and merging into the root.

*Cotyledons* spatulate, petiolate, glabrous; petiole flattened above, convex beneath, dilated and connate at the base, 6 mm. long;

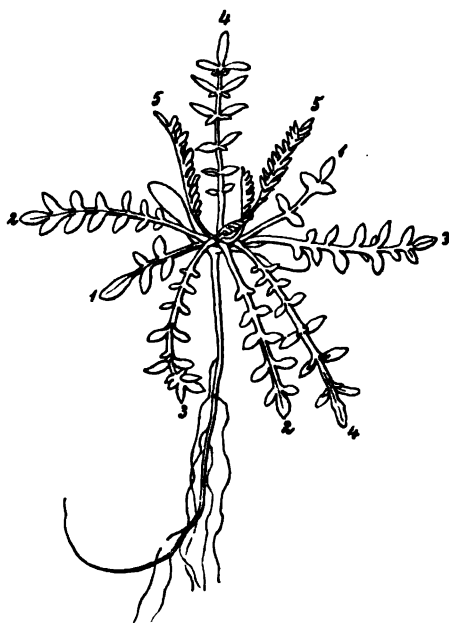


FIG. 527—*Gilia crassifolia*. Nat. size.

lamina oblong, obtuse, tapering at the base, subfleshy, 6 mm. long, 8 mm. wide.

*Stem* annual, developed when about to flower.

*Leaves* simple, radical (and ultimately cauline), opposite, exstipulate, petiolate, glabrous except the petiole, deep green, subfleshy; petioles channelled above, ciliate on the upper edges, dilated at the base.

First pair oblong, pinnatisect with two lateral pairs and a terminal segment, all oval or oblong.

Second pair linear, pinnatisect with numerous oval segments; terminal one obovate.

Third pair linear, pinnatisect; segments small at the base, gradually lengthening towards the apex where they are oblanceolate; larger ones each with a segment on the posterior basal side.

Fourth and fifth pairs similar to the last, but rather longer and more equally developed.

*Gilia squarrosa*, Hook. et Arn.

*Primary root* as in *G. crassifolia*, colourless but with a few short lateral rootlets.

*Hypocotyl* as in *G. crassifolia*.

*Cotyledons* short, linear, obtuse, fleshy, glabrous, 6 mm. long.

*Stem* as in *G. crassifolia*.

*Leaves* simple, radical (and ultimately cauline), opposite, exstipulate, sessile, glandular-hairy, rather densely aggregated.

First pair linear, obtuse, fleshy, similar to the cotyledons but longer and glandular-hairy.

Second pair pinnatifid with two pairs of shortly linear, lateral segments above the middle.

Third pair similar, or with three pairs of segments.

Fourth pair linear-oblong in outline, with numerous alternate or subopposite, linear, slender, aristate segments.

Fifth pair more or less pinnatisect with pinnatifid segments; the ultimate segments or secondary lobes arise from the basal posterior side of the primary segments.

*Gilia lutea*, Steud. (fig. 528).

*Primary root* as in *G. crassifolia*, with small lateral rootlets.

*Hypocotyl* as in *G. crassifolia*.

*Cotyledons* small, spatulate, obtuse, rather fleshy, 5 mm. long including the petiole, glabrous.

*Stem* herbaceous, annual, erect, terete, slender, apparently



branching dichotomously, sparsely and minutely pubescent and scabrous, pale green suffused with red; 1st internode 6 mm. long; 2nd 1 cm.; 3rd 9 mm.

*Leaves* simple, digitately or radiately tri- to multi-sect, cauline, opposite, exstipulate, sessile, deep green, subfleshy, minutely ciliate at the margin, otherwise glabrous.

First pair tripartite with acute segments; lateral segments linear; terminal one much larger, oblanceolate.

Second pair similar, but much larger.

Third pair five-sect; terminal segment oblanceolate; two lateral pairs slender, oblanceolate-linear.

Ultimate leaves seven- to eleven-rayed; segments linear; basal ones shortest and narrowest; all ending in a common subcuneate base.

*Polemonium cæruleum*, L.,  
*var. album*.

*Primary root* slender, tapering, colourless, giving off a few lateral rootlets.

*Hypocotyl* very short, tapering into the root, greenish-white.

*Cotyledons* petiolate; lamina oblong-ovate, obtuse, 7 mm. long, 4 mm. wide; petiole channelled above, 6 mm. long.

*Stem* ultimately stout and short, with very shortly developed internodes.

*Leaves* compound, imparipinnate, radical (and ultimately cauline), alternate, exstipulate, petiolate, glabrous, bright green above, paler beneath; petioles subterete, channelled above, dilated and subclasping at the very base.

No. 1. Pinnately trifoliolate; leaflets ovate; terminal one largest.

No. 2. Pinnately five-foliolate, otherwise like the first; pairs of leaflets frequently unequal.

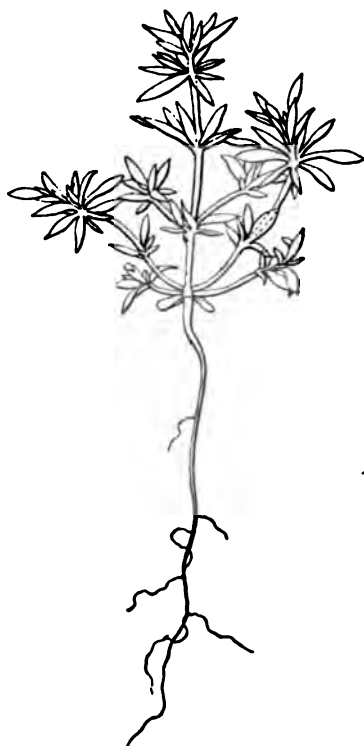


FIG. 528.—*Gilia lutea*. Nat. size.

***Navarettia involucrata*, Ruiz et Pav.**

*Hypocotyl* erect, terete, glabrous, 2.5–4 cm. long, light green, colourless or stained with red.

*Cotyledons* oval, obtuse, entire, with very long petioles, glabrous or with a very few hairs on the petioles, green, rather distinctly pinnatinerved.

*Stem* erect, terete, herbaceous, glabrous, almost colourless or reddish; 1st internode 3–6 mm. long.

*First leaves* compound, pinnate; petioles long, with sometimes a few hairs, exstipulate; leaflets ovate, cuspidate, acute, sessile or shortly petiolate, opposite, glabrous or with a few hairs, light green, one-nerved.

***Cobæa scandens*, Cav. (fig. 529).**

*Ovary* of three to four carpels, surrounded at the base by a large-lobed wavy disk, three- to four-celled, many-ovuled; ovules attached by the ventral aspect, ascending, amphitropous, arranged in two rows, one on each side the middle line of the placental axis and equidistant between that and the margin; micropyle inferior.

*Capsule* large, oblong, smooth, deep green and suffused with a glaucous bloom, ultimately brownish-yellow, three- to four-valved, three- to four-furrowed, dehiscing septicidally at the furrows; placental axis large, forming a triangular or sometimes quadrangular mass occupying the greater part of the interior.



FIG. 529.—*Cobæa scandens*.

Longitudinal section of seed in plane of cotyledons: *E*, endosperm; *n*, notch caused by hilum of another seed,  $\times 2$ .

*Seed* large, much compressed dorsally, oval or subelliptic in outline or somewhat irregular, generally broader and always emarginate at the lower end, and narrowed to an obtuse point at the upper end, winged, brown, overlapping one another from the base upwards; radicle at the basal end; hilum ventral

below the middle of the seed, spatulate in outline; raphe ventral, extending from the hilum to the inner edge of the wing; testa composed of slender fibrous material, mixed with pulpy matter when young.

*Endosperm* in young seed soft, dirty white, enveloping the embryo entirely, ultimately fleshy in the mature seed.

*Embryo* in the centre of the endosperm, straight from first to last, large occupying almost the entire length and breadth of the

interior of the seed ; cotyledons flat, rotund-cordate in the early state, ultimately ovate-cordate, obtuse, entire, alternately penninerved, colourless, but large, green and foliaceous after germination ; radicle short, cylindrical, somewhat pointed.

### Seedling.

*Primary root* normal, long, tapering, with lateral rootlets.

*Hypocotyl* becoming woody, erect, terete, glabrous, suffused with purple, 8 cm. long, 2 mm. thick, giving off adventitious roots from its base.

*Cotyledons* shortly petiolate, large, ovate, obtuse, entire, penninerved, convex above and green suffused with purple, concave beneath, with prominent midrib and primary nerves, 6 cm. long, 3.5 cm. wide ; petiole channelled above, 4 mm. long, 3 mm. wide.

*Stem* erect, terete, and having two decurrent lines on each side, running down from the base of the petioles, purplish, sparsely pubescent with short white or crystalline hairs, flexuose at the nodes ; 1st internode undeveloped ; 2nd 7.2 cm. long, 1.5 mm. thick ; 3rd 5 mm. ; 4th 8.5 mm. or longer. Stem ultimately climbing by tendrils consisting of modified leaflets.

*Leaves* cauline, lower pair opposite, the rest alternate, exstipulate, petiolate, pinnately compound.

Nos. 1 and 2. Opposite, imparipinnate, consisting of three pairs of leaflets and a terminal one ; leaflets half folded up face to face, oblong-lanceolate, acute, entire, subrevolute at the margins and convex above, unequal at the base, petiolate, with a prominent sunk midrib and primary lateral nerves, closely reticulate, sparsely pubescent on the upper surface ; primary midrib channelled above, sparsely pubescent ; petiolules subterete, tapering upwards from a stout base, pubescent, channelled above, 1.6 cm. long.

Nos. 3 and 4. Nearly opposite, sessile, pinnate and terminating in a tendril instead of a leaflet, otherwise similar to Nos. 1 and 2 ; tendril at first straight, alternately branched, slightly scabrous, purple, tapering towards the tip ; branches slender, dichotomous, the ultimate branchlets hooked or clawed.

When the slender tip and branchlets have grappled or coiled round an object, an impulse is communicated to the lower unbranched part, causing it to coil up spirally and draw the plant to the supporting object.

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## HYDROPHYLLACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 825.

*Fruit and Seed.*—The ovary is superior and syncarpous, consisting of two carpels united by their edges only, forming a one-celled ovary with free or parietal placentas, or the latter are protruded into the centre, and touching one another form two spurious cells, or the septa cohere and form two distinct cells with prominent axile placentas. The ovules vary from two to many on each placenta and are anatropous or amphitropous. The fruit is capsular, dehiscing along the middle of each carpellary leaf with the valves bearing the placentas along their faces, or the placentas are erect and parallel with the valves. It more rarely happens that the fruit dehisces at the septa, or irregularly and separating from the axile placentas. The seeds vary in number from two to several, and are oblong, globose or angular. The testa is tubercular or rugose, smooth in one genus, *Conanthus*, with only one species. The endosperm is usually copious, fleshy and sometimes ruminated, surrounding a small embryo. The latter is straight with plano-convex or subterete cotyledons; the radicle is superior or points in various directions in different species.

The seeds of *Nemophila parviflora* are subglobose and variously angled with a rugose testa. The copious endosperm is ruminated. The embryo is small with orbicular cotyledons much shorter than the terete radicle. *N. maculata* has much larger, similarly angled seeds, ruminated endosperm, and a correspondingly large embryo of the same shape as that of *N. parviflora*. The seeds of *Phacelia tanacetifolia* are oblong, obtusely trigonous, and rather small. The embryo is rather elongated and slender, with linear cotyledons in the broader plane of the seed or obliquely to it. The terete radicle is rather elongated.

*Seedlings.*—The cotyledons of this Order are all of simple types, but they show a considerable amount of variation in

different species even of the same genus. Orbicular, obovate, oval, ovate and linear types occur, with some slight modifications.

A number of species of *Nemophila*, including *N. maculata* (fig. 530), have orbicular or suborbicular cotyledons, the petioles of which are dilated and more or less connate. The first two leaves are pinnatisect with three segments, the terminal one of which is the largest and more or less deeply trifid. The following four or more leaves have five segments, the terminal one of which is the smallest. *N. parviflora* agrees somewhat with the above type, but the primary leaves are more distinctly in pairs, and the first two are less deeply divided. The seedling of *N. phacelioides* is chiefly notable for the much greater size of all its parts. The cotyledons are rather strongly penninerved, reticulate and hairy. The first two leaves are pinnatisect with oblong and cuneate, sometimes emarginate segments. The segments of the next two leaves are more or less deeply toothed or lobed; and all are hairy like the cotyledons.

A different type of seedling is met with in *Nemophila insignis*. The cotyledons are obovate-oblong, emarginate, trinerved and hairy. The first four leaves are pinnatifid with rounded segments. The cotyledons of *Phacelia bipinnatifida* are oval. The first leaf is triangular, subcordate at the base, and shallowly lobed. The next leaf is more decidedly characterised in this way, and has sometimes a separate segment or two cut away from the main portion of the lamina. The third leaf is more oblong and more deeply divided.

The whole seedling of *Romanzoffia sitchensis* closely resembles that of a *Ranunculus*. The base of the petioles of the cotyledons and leaves is dilated and sheathing. The lamina of the cotyledons is roundly-ovate or triangular, trinerved and glabrous. The first four leaves are palmately five-nerved and lobed with rather deep auricles. *Wigandia Vigieri* (fig. 532) is notable for the very small size of its ovate or rhomboid cotyledons. The first pair of leaves are ovate and entire, while the second pair are serrate. Succeeding leaves are much larger, oblong with a cordate base, and ultimately attain a great size.

The cotyledons of *Phacelia tanacetifolia* (fig. 531) are linear, petiolate and one-nerved. The first two pairs of leaves are opposite and twice divided with ovate-oblong primary segments. The secondary divisions are entire or toothed. The first three leaves of *Phacelia Wrangeliana* are small and ovate.

***Nemophila maculata*, Benth.**

*Ovary* two- to twelve-ovuled; ovules pendulous, anatropous.

*Fruit* a one-seeded capsule.

*Seed* variously angled, generally almost subrotund, from 3–4 mm. in diameter; testa rugose, dark brownish; hilum inconspicuous; seed slightly flattened laterally.

*Endosperm* light brown, fleshy, copious, ruminated.

*Embryo* straight, embedded in the endosperm, colourless, cotyledons suborbicular or oblong, obtuse, entire, sessile, plano-convex, closely adpressed with their edges to the axis; radicle terete, obtuse, rather longer than the cotyledons, which lie in the broader way of the seed.

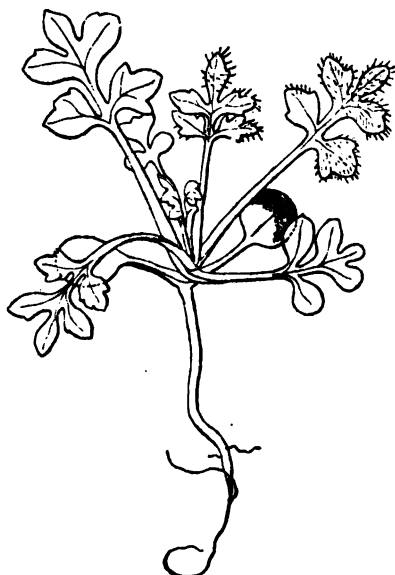


FIG. 530.—*Nemophila maculata*.  
Nat. size.

**Seedling (fig. 530).**

*Primary root* suddenly terminating in a slender point and furnished with a few lateral fibres, annual.

*Hypocotyl* tapering downwards, subflexuose, terete, sparsely pubescent, mostly subterranean and colourless, brownish at the top.

*Cotyledons* foliaceous, hairy; petiole channelled above, dilated and connate at the base, 1 cm. long; limb rotund, concave on the upper side, about 8 mm. in diameter.

*Stem* annual, internodes undeveloped in the young state.

*Leaves* simple, pinnatisect, radical (and ultimately cauline also), alternate, exstipulate, petiolate, coarsely hairy on all parts, deep green, sublucid.

No. 1. Pinnatisect; terminal segment largest, tridentate; lateral segments obovate.

No. 2. Pinnatisect; terminal segment transversely broader than long, trifid with rounded, obtuse, apiculate lobes; lateral segments obovate.

No. 3. Pinnatisect; basal lobes broadly subrhomboid, tridentate; middle pair of lobes irregular, subobovate, apiculate; terminal lobe small, obovate, apiculate.

Nos. 4 and 5. Similar to the last.

No. 6. Pinnatisect; basal pair of segments deeply dentate, ovate, with apiculate teeth; middle pair of segments tridentate with apiculate teeth; terminal segment obovate with a tooth on one side.

More segments are added to the leaf by segmentation of the terminal lobe as the plant gains in size and strength.

***Nemophila insignis, Benth.***

*Hypocotyl* erect, terete, glabrous, short, from 5–8 mm. long, almost colourless.

*Cotyledons* obovate-oblong, obtuse, slightly emarginate, rather unequal, petiolate, hairy on the upper side, glabrous on the lower, green, indistinctly trinerved; petioles flat, hairy.

*Stem* as in *N. maculata*.

*First leaves* pinnatifid, radical, opposite, oblong, obtuse, exstipulate, petiolate; lobes obovate or subrotund, entire or slightly lobed, pubescent, green, pinnatinerved; petiole flat, pubescent, very slightly channelled on the upper side.

***Nemophila phacelioides, Nutt.***

*Hypocotyl* short, terete, glabrous, hardly appearing above the soil.

*Cotyledons* large, subrotund, from 8–8.5 cm. in diameter, with a long petiole, obtuse, entire, sub-fleshy, covered with minute hairs on the upper side, glabrous beneath, light green, distinctly pinnatinerved.

*Stem* as in *N. maculata*.

*First leaves* simple, pinnatifid or pinnatisect, petiolate, exstipulate, radical, alternate, covered with bristly hairs above, glabrous beneath; lobes alternate, almost petiolate, obovate-oblong, entire or bi- to tri-lobed, light green, pinnatinerved.

***Nemophila parviflora, Benth.***

*Ovary and fruit* as in *N. maculata*.

*Seed* smaller than in *N. maculata*; testa yellowish-red, thin, becoming almost transparent near the apex.

*Endosperm* as in *N. maculata*, but almost colourless.

*Embryo* as in *N. maculata*.

### Seedling.

*Primary root* tapering downwards and giving off strong lateral rootlets, annual.

*Hypocotyl* very short, erect, terete, slightly hairy or scaberulous, 4-6 mm. long, and tapering indistinguishably into the radicle.

*Cotyledons* more or less orbicular, petiolate, entire and tipped with a glandular mucro, or appearing sometimes slightly emarginate, rigid, subfleshy, usually concave owing to the centre growing faster than the margins, scabrido-pubescent on both sides, with an indistinct midrib but no other venation, deep green above, paler beneath or violet; lamina 6.5-9 mm. long, 5.5-8.5 mm. wide; petiole semiterete, flattened above, scabrido-pubescent, horizontal, dilated and connate at the base, 4-6 mm. long.

*Stem* diffuse, annual, with the primary internodes undeveloped.

*Leaves* simple, radical and cauline, alternate, or lower opposite, exstipulate, petiolate, lobed, pinnatifid and pinnatisect, with alternate ascending nerves running into each of the principal segments and lobes, scabrido-pubescent all over, more or less concave or incurved at the margin or flat when young, deep green above, paler beneath; petioles semiterete, flattened above or shallowly grooved, dilated at the base and amplexicaul.

First pair pinnatifid, with one obovate, lateral lobe on each side, and a terminal broadly cuneate trifid one.

Second pair pinnatifid, with a pair of broadly cuneate, slightly dentate lateral lobes, and a broadly cuneate or transversely rhomboid, deeply trifid and slightly toothed terminal segment.

Third and fourth pairs pinnatisect at the base, and pinnatifid upwards, with the segments mostly trifid.

### *Phacelia tanacetifolia*, Benth.

*Ovary* few-ovuled; ovules erect, anatropous; micropyle inferior.

*Fruit* a capsule, two-celled, two- to three-seeded.

*Seed* oblong, 1-1.5 mm. long, considerably flattened laterally; testa rugose, membranous; hilum inconspicuous.

*Endosperm* copious, fleshy, almost colourless.

*Embryo* straight, embedded in the endosperm, either at or very near the centre of the seed; cotyledons linear, obtuse, entire, almost flat, closely adpressed, lying either in the broader way of the seed, or obliquely to it; radicle long, terete, obtuse, narrow, shorter than the cotyledons.



**Seedling (fig. 581).**

*Primary root* long, tapering downwards, with a few lateral rootlets, annual.

*Hypocotyl* erect, terete, minutely and thinly pubescent, pale green or almost colourless, 1·8–2·5 cm. long.

*Cotyledons* linear, obtuse, petiolate, minutely pubescent, with a distinct midrib but no other venation visible in the fresh state; lamina 1·8–1·5 cm. long, 8–8·5 mm. wide, narrowed into the petiole; petiole semiterete, channelled above, pubescent on the edges above, or nearly glabrous, 7–9 mm. long.

*Stem* erect, terete, thinly glandular - pubescent with decurved hairs, pale green; 1st internode about 1·8 cm. long; 2nd about 2·8 cm.

*Leaves* simple, pinnatisect, cauline, opposite (at least in the lower part of the plant), exstipulate, petiolate, pubescent on both surfaces with bulbous - rooted short hairs directed towards the apex of the leaf and densely dotted with sessile glands; primary nerves opposite or alternate, ascending; secondary nerves alternate, ascending; petioles semiterete, shallowly channelled above, pubescent or more or less glandular - pubescent, tapering upwards from a broadish, semi-amplexicaul base.

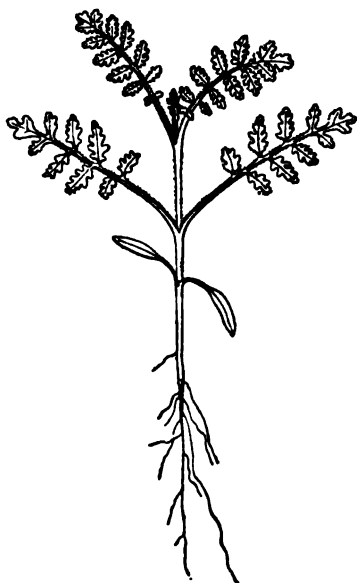


FIG. 581.—*Phacelia tanacetifolia*.  
Half nat. size.

Nos. 1 and 2. Opposite, oblong in outline, pinnatisect, pinnatifid; primary segments ovate-oblong, obtuse, shortly stalked; secondary segments short, rotund-oblong, obtuse, entire.

Nos. 3 and 4. Opposite, lanceolate or linear in outline, pinnatisect, pinnatifid; primary segments oblong, obtuse, narrowed towards the base and shortly stalked; secondary segments oblong, obtuse, slightly toothed.

***Phacelia bipinnatifida*, Michx.?**

*Primary root* as in *P. tanacetifolia*.

*Hypocotyl* short, obconical, suddenly tapering into the root.

*Cotyledons* oval, submucronate, 1.1 cm. long, 8 mm. wide, sparsely hairy on the nerves, petiolate; petiole channelled above, dilated and connate at the base, 1 cm. long.

*Stem* ultimately developed when about to flower, annual.

*Leaves* radical (and ultimately cauline), alternate, exstipulate, petiolate, coarsely hairy especially when young and on the petioles; petioles channelled above, dilated and subamplexicaul at the base.

No. 1. Triangular-subcordate, coarsely dentate or lobulate, rather indistinctly nerved above, more prominently beneath.

No. 2. More elongated and pinnatifid or pinnatisect; terminal segment very large, five-lobed; lateral segments one or two, very small, oval or elliptic.

No. 8. Pinnatisect with one to two small lateral segments, and a large terminal sub-bipinnatifid one.

Ultimate leaves lyrate-pinnatisect, pinnatifid; lateral segments alternate, very irregular in size and division, ovate or oblong, acutely incise-serrate or pinnatifid, frequently exhibiting small intermediate segments cut away from the posterior basal side; terminal segment much the largest, triangular, trinerved, lobed or pinnatifid, and coarsely incise-serrate, often with small oval, or elliptic, acute, entire segments cut away from its base.

*Romanzoffia sitchensis*, Cham.?

*Primary root* tapering downwards and giving off a few lateral rootlets, soon superseded by numerous, strong adventitious roots from the base of the cotyledons and leaves.

*Hypocotyl* undeveloped.

*Cotyledons* rotund-ovate, obtuse, entire, petiolate, trinerved, with the lateral nerves incurved and uniting with the midrib below the apex, minutely glandular-pubescent on both surfaces, deep opaque green above, paler beneath, tipped with a gland; lamina 8-4.25 mm. long, 2.5-4.25 mm. wide; petiole flattened above, convex on the back, tapering upwards from a broad, dilated and slightly connate base, minutely glandular-pubescent, reddish-purple, 2.5-6 mm. long.

*Stem* herbaceous, and developed only when about to flower, about six inches long; primary internodes undeveloped.

*Leaves* radical and cauline, alternate, exstipulate, petiolate, palmately nerved and toothed or lobulate, slightly hairy on both surfaces with pale-coloured jointed hairs, deep opaque green above, paler beneath; petioles semiterete, slightly flattened above, much dilated and clasping at the base, hairy or almost villous with pale jointed hairs, especially in the hollow dilated bases.

No. 1. Cordate, palmately three- to five-nerved, and toothed with glandular-mucronate, obtuse teeth.

Nos. 2 and 3. Reniform, five- or six-nerved with glandular-mucronate, obtuse teeth.

No. 4. Reniform, palmately seven-nerved and toothed or sublobulate.

**Wigandia Vigieri**, *Hort.* (fig. 592).

*Primary root* tender, succulent, flexuose, frequently giving off rootlets at the angles.

*Hypocotyl* short, tapering downwards, colourless under the soil, red above it and hairy, 8-5 mm. long.

*Cotyledons* very small, petiolate, pubescent, pale green; lamina rhomboid, acute, 2 mm. long, 1.5 mm. wide; petiole 1-1.25 mm. long.

*Stem* erect, terete, densely and coarsely hairy, succulent in the young stage, purple; internodes very variable, bringing the early leaves nearly or quite opposite.

*Leaves* simple, cauline, alternate (or a few of the seedling leaves opposite), exstipulate, petiolate, coarsely hairy on both sides, deep green above with a purple midrib and frequently splashed with purple, paler beneath and irregularly splashed with purple, alternately penninerved; petioles subterete, narrowly channelled above, tapering upwards from a stout base.

Nos. 1 and 2. Small, opposite, ovate, obtuse, entire.

Nos. 3 and 4. Opposite, ovate, subacute or obtuse, serrate.

No. 5. Alternate, oblong, acute, cordate at the base, irregularly or somewhat doubly dentate.

No. 6. Cordate-oblong, obtuse, doubly dentate.

No. 7 and 8. Cordate, elongate, acute, doubly dentate.



FIG. 592.  
*Wigandia Vigieri*.  
Nat. size.

## BORAGINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 832.

**Fruit and Seed.**—The ovary is superior, syncarpous, and consists of two carpels each of which is two-ovuled. Sometimes it is entire, or again more or less deeply four-lobed and two-celled, or the cells may be divided by spurious septa or

strongly involute placentas, thus making the ovary more or less distinctly four-celled, each cell with a single ovule. In other cases the ovary is four-lobed and four-celled, with the central part entire and together with the gynobasic style persistent. It more rarely happens that the lobes are connate in pairs, and each two-celled, or that there are two lobes, each containing one ovule. The ovules are erect, oblique or horizontal, and inserted at the base or towards the apex of axile placentas. The micropyle is superior or faces the axis. The fruit is drupaceous, and two- to four-celled with a woody endocarp, or breaks up into two to four pyrenes, or fewer by abortion. In these cases the exocarp is fleshy, baccate or thin. There are many familiar instances where the fruit breaks up into four nutlets, or fewer by abortion, with a hard or sometimes fleshy exocarp or shell, one-seeded and indehiscent. The seed like the ovule is erect or oblique, rarely horizontal, straight or incurved, and conforming to the interior of the cells, pyrene, or nutlet as the case may be. The testa is membranous. Endosperm is copious and fleshy, or scanty, and at other times entirely wanting. The embryo is straight or curved in conformity with the seed, while the cotyledons vary greatly, being flat, plano-convex, thick and fleshy, and entire. A few cases occur where the cotyledons are bifid, and others where they are much plaited. The radicle is generally short and superior, or facing the axis.

The cotyledons are plaited in the tribe Cordieæ, bipartite in the genus *Amsinckia*, and the radicle is subinferior in some members of the subtribe *Cynoglosseæ*.

The plaited character of the cotyledons is well shown by *Cordia subcordata* (fig. 534). The folds are longitudinal and deep, causing the cotyledons to be toothed or notched at the apex. The fruit is undivided, nut-like and four-celled, but three out of the four cells are usually empty or contain aborted ovules only. The endocarp is woody or bony, elevated on its outer surface into longitudinal and transverse ridges, and covered by a fleshy exocarp, becoming cortical when dry. The plaiting of the cotyledons in the nut of *C. subopposita* is less deep and perhaps more irregular. A section shows two small and two large but empty cells, while a fifth con-

tains a perfect embryo. This number of cells is however probably quite abnormal. An imperfect fruit of *C. grandifolia* (fig. 533) shows three small cells towards one side of the endocarp, while there is a larger but empty one in the centre.

The most familiar examples of the Boraginæ have fruit which breaks up into four one-seeded nutlets to the interior of which the seeds and embryo conform. Endosperm is usually wanting and the cotyledons are plano-convex and rather fleshy. *Borago officinalis* is an example of this type. The embryo is straight and ovoid, with oval plano-convex cotyledons. The nutlets of *Cynoglossum vulgare* are larger, covered with coarse, hooked bristles, obovoid and somewhat compressed. The cotyledons are broadly obovate. The epicarp of *Symphytum aspernum* is unequally thickened, one side having a thick wall, but it is quite smooth. The cotyledons are oval or oblong, rounded at the end and plano-convex. The nutlets of *Myosotis arvensis* are ovoid, smooth, and very small. The cotyledons are broadly obovate or oval and otherwise quite typical. The nutlets of *Lithospermum officinale* are also ovoid and polished as in *Myosotis*, but they are much larger. The walls are very thick and bony, and the seed with the embryo conforms closely to the interior. The cotyledons are broadly oval or obovate and entire. The nutlets of *Echium vulgare* are ovoid, subconical, slightly incurved upwards, keeled on the dorsal aspect and covered all over with little warts or protuberances. The hilum of the seed is above the middle of the ventral aspect. The seed and embryo are slightly incurved in conformity with the nutlet. The cotyledons are broadly oblong or oval. In all of the above cases belonging to this type the radicle is superior and very short.

A third type is met with in *Amsinckia*, the cotyledons of which are bipartite. The nutlets of *A. longifolia* are ovoid, elongated, somewhat trigonous and rugose or warted on the surface. The cotyledons have oblong lobes so arranged as to occupy the angles of the seed and fruit. The angular character of the nutlet may explain the necessity for fission of the cotyledons which would otherwise fit awkwardly into the angles.

*Seedlings.*—There are at least five or six different types of cotyledons amongst the Boraginæ. One of the most remarkable is that represented by *Cordia latifolia* which has broad subrhomboid-cuneate, somewhat plaited, five-nerved cotyledons. The three primary nerves are much branched with the branches terminating in the notches between the crenatures of the apical margin of the lamina. The crenatures are due to the way in which the large cotyledons are longitudinally folded or plaited in the seed. Other instances are met with in which the midrib ends in an apical sinus, such as *Brassica* and *Convolvulus* as well as all or most cases where the cotyledons are bifid or emarginate, but the case of numerous crenatures with the stronger secondary as well as the primary veins ending in the notches is probably unique as far as the genus *Cordia* is concerned. The hypocotyl of *C. latifolia* is very short. The first leaf is small, oblong and entire, while the two following leaves are much larger and thinly serrated above the middle. The seedling of *C. subcordata* (fig. 535) is altogether taller and more robust with a long hypocotyl. The cotyledons are transversely oval, longitudinally plicate, and otherwise like those of *C. latifolia*. The first leaf is ovate, acuminate, and the second cordate. The cotyledons of *C. decandra* are obovate-elliptic, plicate, crenate at the apical margin, pubescent and penninerved. An exceptional case occurs in *C. ferruginea* which has broadly obovate-cuneate, trinerved, entire cotyledons. The first two leaves are oblong-lanceolate and subopposite.

A third type occurs in *Lithospermum officinale* (fig. 538) which has obovate or roundly-elliptic, emarginate cotyledons; hairy on the upper surface. The first two leaves are opposite but unequal in size, oblong-elliptic and entire. The cotyledons of *Echium canescens* are suborbicular or oblate and hairy, with a wide shallow apical sinus.

The cotyledons of some species vary between obovate, oblong-obovate and spatulate. Those of *Anchusa capensis* are broadly obovate, entire, penninerved and hairy. The first leaf is lanceolate-oblong, tapering to the base, penninerved and hairy. Those of *Echium violaceum* differ chiefly in having a more oval lamina. The first pair of leaves are

oblong-oval and opposite. The seedling of *Eritrichium bar-bigerum* is altogether smaller, with spathulate hairy cotyledons showing only a somewhat obscure midrib.

Suborbicular cotyledons occur in a number of species including *Tournefortia ferruginea* (fig. 536). They are subtruncate at the base, trinerved, finely pubescent with rather slender petioles. Those of *Omphalodes linifolia* are smaller, glabrous, glaucous and one-nerved. In the case of *Echium Decaisnei* they are small, rotund, and concave. The leaves are all lanceolate or oblong-lanceolate, finely and densely hairy on both surfaces, and appear to vary only in size from the seedling onward to the adult state.

A most remarkable type is met with amongst the species of *Amsinckia* in which the cotyledons are bifid or bipartite. In *A. intermedia* (fig. 537) they are cut down to the petioles, with spathulate, hairy, one-nerved, entire, somewhat stalked and divaricate lobes. Two or more of the primary leaves are linear and hairy.

### *Cordia subopposita*, DC.

*Fruit* a nut, or drupe according to some authors, oblong-ellipsoid, tipped with the remains of the terminal style, glabrous, dark-coloured, four- rarely three- or five-celled, or by abortion reduced to one or more fertile or seed-bearing cells, while the others are empty; exocarp in the dried state forming a layer of dry, softish, cellular material; endocarp bony, ellipsoid, subtetragonal, tapering above and below the middle, with four slightly excavated or sculptured sides above the middle, slightly notched at the base and shortly bifid at the apex, pale brown or straw-coloured.

*Seed* obovoid, somewhat compressed laterally, and subconical at the tip; testa thin, membranous, smooth, white, micropyle at the upper and pointed end of the seed; hilum lateral and attached to the inner angle of the cell.

*Endosperm* absent.

*Embryo* straight, large, filling the entire cavity of the seed, colourless; cotyledons very broad, rounded, crenate, much plaited from the testa towards the centre of the seed so as to occupy the whole of the space, thick and subfleshy; radicle short, stout, turbinate, obtuse, lying in the conical tip of the seed, and pointing to the base of the style.

***Cordia grandifolia*, DC. (fig. 588).**

*Fruit* a drupe, or rather a nut when mature and dry, four-celled, but usually only one cell contains a perfect embryo, which is transverse to the axis and oblong-subreniform, closely covered with fine adpressed hairs, lying in the broad, almost flattened, five-lobed calyx; pericarp crustaceous when dry or subcoriaceous; endocarp bony, except at the receptacle where a cavity is left filled with rather soft, cortical, pale-coloured tissue, nearly smooth except on

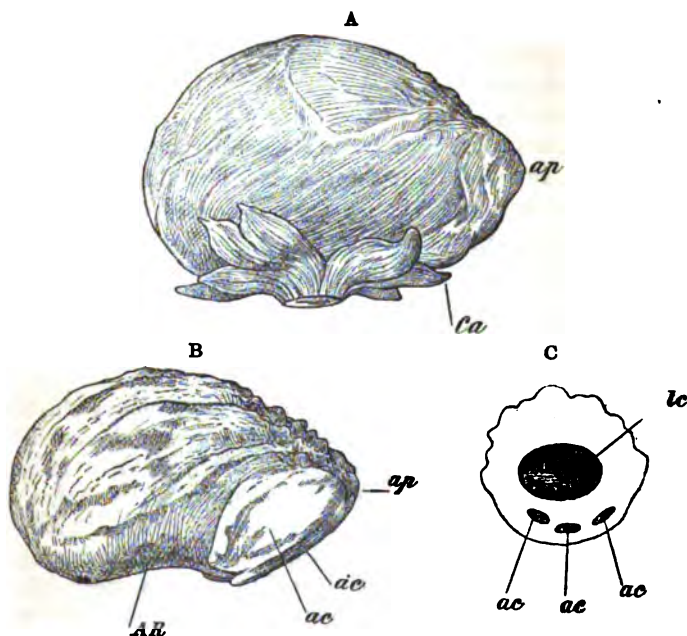


FIG. 588.—*Cordia grandifolia*. A, fruit,  $\times 4$ : Ca, calyx; ap, apex of fruit. B, endocarp and seed, or nut,  $\times 4$ : AR, attachment to receptacle; ap, apex of nut; ac, ac, aborted cells of ovary. C, transverse section of nut,  $\times 4$ : ac, ac, ac, aborted cells of ovary; lc, large cell usually containing a seed, but here empty.

the upper side which is raised into numerous tooth-like elevations, smooth and differently coloured on the ventral aspect near the top, denoting the presence of the three aborted lobes of the ovary. A transverse section of this part showed one large and three small cavities, the latter of which were empty.

***Cordia subcordata*, Lam. (fig. 584).**

*Fruit* a nut (by some called a drupe) enclosed in the enlarged



calyx-tube, four-celled, four-seeded, or by abortion fewer, indehiscent, and not separating into nutlets as in the more typical Boragineæ; epicarp forming a thick cortical pale brown stratum; the bony endocarp with longitudinal and a few more or less acute transverse ridges, embedded in the cortical layer. In the fruit examined one cell had a perfect embryo or seed, while all the other ovules were aborted and the cells very small.

*Seed* conforming to the interior of the cell which it fills, ovoid-conical, glabrous, pale-coloured; testa very thin, soft, separable into an outer cortical layer, and an inner white layer; micropyle superior at the pointed end of the seed, and indicated by a small dark-coloured spot.

*Endosperm* absent.

*Embryo* large, straight, occupying the whole interior of the seed; cotyledons large, much plicate longitudinally and crenate at the margin, folded from the circumference towards the centre of the seed, and from thence back again, and this is continued all round the interior of the seed, rather thick, fleshy, and colourless; radicle very short, stout, turbinate, obtuse, lying externally to the cotyledons and occupying the conical tip of the seed, close to the micropyle which is dark-coloured.

*Seedling* (fig. 585).

*Hypocotyl* suffruticose, densely covered with short stiff hairs, 7 cm. long.

*Cotyledons* petiolate, soft and succulent, becoming coriaceous, transversely oval, roundish or oblong, crenate, plicate, subcordate at the base, palmately three- to five-nerved with numerous strong lateral veins ascending from the primary ones, pale green above and covered with a dense adpressed pubescence, paler beneath and glabrous except on the nerves; petiole somewhat flattened above, convex beneath, densely pubescent, 8.5 mm. long.

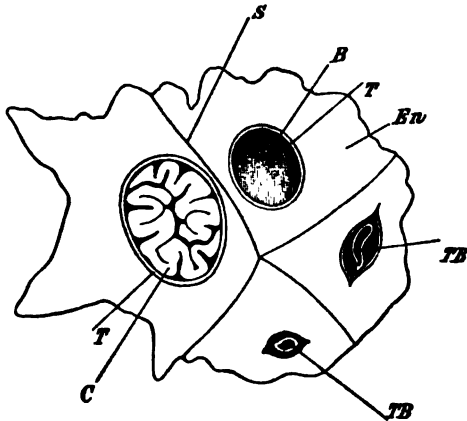


FIG. 584.—*Cordia subcordata*. Transverse section of nut,  $\times 4$ : T, testa; C, cotyledon; TB, TB, testa of barren seeds in empty cells; En, endocarp; B, barren cell with testa, T; S, sutural line.

*Stem* erect, terete, becoming woody, densely covered with an adpressed or ascending pubescence, pale green; 1st internode 2·3 cm. long, 1·5 mm. thick; 2nd (when sketched) 5 mm. long.



FIG. 685.—*Cordia subcordata*.  
Half nat. size.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, sparsely pubescent on both surfaces with short, adpressed, white, rather stiff hairs, quite entire.

No. 1. Ovate, acuminate, very unequal at the base, subconcave, involute and wavy at the margin, penninerved and reticulate, acute; petiole flattened above, convex beneath, covered with a dense adpressed pubescence pointing towards the apex, 6 mm. long.

No. 2. Cordate, acute, slightly unequal at the base, subtrinnerved and reticulate; petiole 5 mm. long.

### *Cordia latifolia*, Roxb.

*Hypocotyl* erect, terete, stout, fleshy, glabrous, green.

*Cotyledons* very large, and similar to those of *C. subcordata*.

*Stem* erect, terete, hairy, pale green, ultimately woody; 1st internode 5 mm. long; 2nd 1·25 mm.; 3rd 1 mm.

*Leaves* alternately and ascendingly penninerved (with the nerves ending in marginal serratures), reticulate, minutely ciliate, and hairy on the midrib, otherwise glabrous, membranous, light green; petiole stout, short, semiterete, channelled above, hairy.

No. 1. Oblong, obtuse.

No. 2. Cuneate, obovate, mucronate, cuspidate, irregularly serrate above the middle, with obtuse mucronate serratures.

No. 3. Oblong-obovate, otherwise like the last.

### *Cordia decandra*, Hook. et Arn.

*Hypocotyl* long, stout, 2·5–3 cm. long, pubescent, terete, light green or almost colourless.

*Cotyledons* obovate-elliptic, obtuse, crenate, wrinkled, wide, subsessile, pubescent, green, very distinctly pinnatinerved.

***Cordia ferruginea*, Roem. et Schult.**

*Hypocotyl* erect, terete, minutely pubescent, 1-2.5 cm. long, light green or almost colourless.

*Cotyledons* broadly obovate, obtuse, entire, cuneate at the base, petiolate, glabrous, green, brighter beneath, trinerved.

*Stem* erect, terete, herbaceous, minutely pubescent; 1st internode 1.25-2 mm. long.

*Leaves*.—First pair simple, entire, cauline, subopposite, lanceolate, acute, with short petioles, exstipulate, hairy, green, pinnatinerved.

***Tournefortia ferruginea*, Lam. (fig. 536).**

*Hypocotyl* erect, terete, pubescent, stoutish, 1.5-2.2 mm. long, light green or almost colourless.

*Cotyledons* broadly subrotund, somewhat truncate at the base, obtuse, entire, petiolate, minutely pubescent, green, trinerved; petioles rather flat. The cotyledons in some cases appear to have considerable difficulty in freeing themselves from the woody testa.

*Stem* erect, terete, herbaceous, pubescent, ultimately woody; 1st internode 6-10 mm. long; 2nd 5-6 mm.

*First leaves* simple, entire, cauline, opposite, decussate, exstipulate, petiolate, ovately oval, obtuse, ciliate, densely pubescent, green, somewhat wrinkled, pinnatinerved; petioles long, pubescent, channelled above.

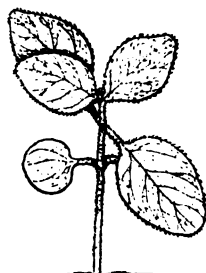


FIG. 536.—*Tournefortia ferruginea*.  
Half nat. size.

***Omphalodes linifolia*, Moench.**

*Hypocotyl* erect, terete, glabrous, light green or colourless, 6-8 mm. long.

*Cotyledons* rotund, obtuse, entire, petiolate, glabrous, pale subglaucous-green, one-nerved; petioles broad, rather flat and shallowly channelled on the upper face.

*Stem* with primary internodes undeveloped, annual.

*First leaves* simple, entire, cauline, opposite, afterwards alternate, broadly spatulate or obovate, obtuse, petiolate, exstipulate, glabrous, pale glaucous-green, very indistinctly pinnatinerved; petioles broad, flat, shallowly channelled on the upper face.

***Cynoglossum vulgare*, Gldenst.**

*Ovary* of two carpels, each two-ovuled; ovules anatropous, pendulous or almost horizontal; micropyle superior.

*Fruit* consisting of four nutlets, the pericarps of which are covered with coarse hooked bristles.

*Seed* conforming in shape to the fruit, obovate, obtuse, exalbuminous, considerably flattened; testa smooth, membranous; hilum conspicuous.

*Embryo* straight, filling the seed, colourless; cotyledons broadly obovate, obtuse, entire, plano-convex, lying face to face the broad way of the seed with their faces to the axis; radicle short, obtuse, terete, much shorter than the cotyledons.

In *C. furcatum*, Wall., the seed is similar in all respects to that of *C. vulgare*, but much smaller, more flattened, and the pericarp is covered with proportionally longer bristles.

***Eritrichium barbigerum*, A. Gray.**

*Hypocotyl* short, erect, terete, 1-1.5 mm. long, green or almost colourless.

*Cotyledons* subfleshy, spatulate, obtuse, entire, tapering to the base, covered with rather stiff hairs on the upper side, glabrous beneath, green, indistinctly one-nerved.

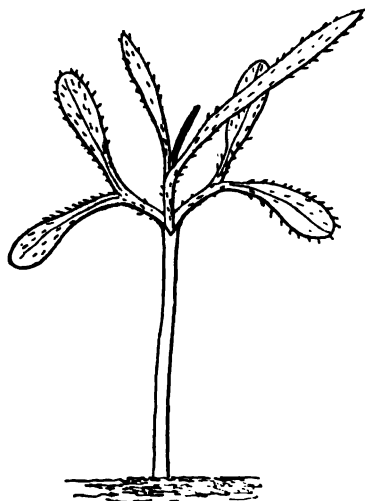


FIG. 587.—*Amsinckia intermedia*,  $\times 2$ .

*Stem* erect, terete, hairy, herbaceous; 1st internode .75-1.25 mm. long; 2nd shorter.

*First leaves* simple, entire, cauline, opposite, decussate, sessile, tapering to the base, exstipulate, spatulate-linear, obtuse, covered with rather stiff hairs or bristles, green, distinctly one-nerved.

***Amsinckia intermedia*, Fisch. et Mey. (fig. 587).**

*Hypocotyl* erect, terete, glabrous, 1.6-2 cm. long, light green.

*Cotyledons* deeply bipartite, divided nearly to the base, with spatulate, obtuse, somewhat stalked, one-nerved, hairy, divaricate divisions. When the seedling first appears above ground the segments are linear, erect, but soon diverge, widen and lengthen till they become spatulate.

*Leaves* simple, cauline, alternate, exstipulate, hairy.

Nos. 1 and 2. Linear, subacute, entire.

***Borago officinalis*, L.**

*Pistil* syncarpous, superior ; ovary of two carpels, deeply divided into four parts, which ultimately fall away from the receptacle as four nutlets ; nutlets erect, oblong, terminated by an acute shallow ridge that runs along the apex and down the inner angle, constricted a little above the base giving the latter a tumid appearance, striated longitudinally with shallow, more or less toothed or muricated ridges on all sides, pale green when immature, ultimately brown ; style gynobasic ; ovules solitary in each of the four parts of the ovary, pendulous, anatropous ; micropyle close to or at the apex.

*Fruit* breaking up into four indehiscent nutlets, which before maturity are seated on a tumid or fleshy body, rounded on all sides except where the seed comes in contact with it.

*Seed* ovoid-oblong, smooth, with a broad base and suddenly tapered to a small point at the apex, pale green when immature, conforming to the smooth inner surface of the pericarp from which it never escapes ; radicle superior or at the apex of the seed, forming a small turbinate point.

*Endosperm* absent.

*Embryo* always straight, oval or elliptic in outline, fleshy, milk-white, suspended from the narrow apex of the seed ; cotyledons plano-convex, applied face to face, oval or elliptic in outline, perfectly straight and entire, rather rounded at the apex and tapering to the small turbinate radicle.

***Anchusa capensis*, Thunbg.**

*Hypocotyl* erect, terete, 4-5 mm. long, light green or colourless, glabrous.

*Cotyledons* broadly obovate-oblong, obtuse, entire, shortly petiolate, hispid above, glabrous beneath, green, indistinctly pinnatinerved like the leaves.

*Stem* with the primary internodes undeveloped.

*First leaves* simple, entire, radical, alternate, oblong, obtuse, tapering at the base to a broad petiole, exstipulate, hispid, green, pinnatinerved.

***Myosotis arvensis*, Hoffm.**

*Fruit* of four nutlets, each one-seeded and oval, with their pericarps smooth and greenish.

*Seed* conforming in shape to the nutlets from .75-1 mm. long, slightly laterally flattened ; hilum inconspicuous.

*Endosperm* wanting.

*Embryo* straight, filling the seed, colourless ; cotyledons broadly

obovate, obtuse, entire, lying in the broad way of the seed with their edges to the axis; radicle short, terete, obtuse, much shorter than the cotyledons.

***Lithospermum officinale*, L.**

*Fruit* of four nutlets, or fewer by abortion, each one-seeded, ovoid; walls of nutlet thick, woody, externally bluish-white, of stony hardness and appearing enamelled.

*Seed* ovoid, conforming to the interior of the nutlet, to which it is closely applied, occupying the whole of the interior except a small empty space at the ventral suture, laterally attached to the placenta, and by growth subsequent to fertilisation appearing basally attached or nearly so; radicle superior.

*Endosperm* absent.

*Embryo* straight, large, obovoid, pale yellowish-white, occupying the whole interior of the seed; cotyledons oval, rounded and entire at the apex, plano-convex and thick; radicle turbinate, obtuse, much shorter than the cotyledons and directed into the obtusely conical point of the nutlet and seed.

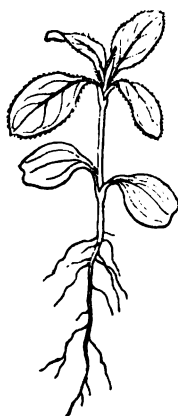


FIG. 588.  
*Lithospermum*  
*officinale*.  
Half. nat. size.

**Seedling (fig. 588).**

*Primary root* normal, tapering, fibrous.

*Hypocotyl* erect, terete, pale green, pubescent, 3–9 mm. long.

*Cotyledons* obovate or subrotund-elliptic, emarginate, tapering into the petiole, light green, with short, bulbous-rooted hairs on the margin and upper surface, nearly glabrous beneath, with a distinct midrib but no lateral nerves; lamina 1.5 cm. long, 1–1.8 cm. wide; petiole broad, shallowly grooved above, perfoliate at the base, closely pubescent, pale green, 6–8 mm. long.

*Stem* herbaceous, erect, terete, closely covered with adpressed pubescence, directed upwards, pale green; 1st internode 1.8–2.7 cm. long; 2nd undeveloped; 3rd slightly elongated.

*Leaves* simple, entire, cauline, alternate (first two opposite), exstipulate, petiolate, covered all over with subadpressed, bulbous-rooted hairs, pale green; petioles rather broad, flattened, shallowly grooved above, hairy like the leaf, semiamplexicaul at the base.

Nos. 1 and 2. Oblong-elliptic, minutely cuspidate, opposite, but unequal in size, with a few alternate, ascending nerves.

Nos. 3 and 4. Slightly alternating with each other, lanceolate-

elliptic or narrowly elliptic, minutely cuspidate, with a few alternate, ascending nerves.

Ultimate leaves narrowly lanceolate.

By bleaching the cotyledons it may be seen that two pairs of nerves arise in the petiole, the lower of which is short, but the next pair follows the curve of the cotyledon at some distance from the margin, and unites with a third pair arising below the middle of the cotyledon, and describing a curve joins the midrib close to the apical sinus. Smaller branches anastomose copiously with all these.

Stomata are numerous on the under side, fewer on the upper. The epidermal cells are very wavy on the under side, but less so above.

The margin of the cotyledon and the base of the sinus especially have large open pores. The thickened apex of the midrib shows a few discoloured openings on the upper surface, but more numerous and conspicuous below. They are rounder than the stomata, and some of them at least are surrounded with four guard cells. The emargination of the cotyledons takes place after germination, and is due to the tissues on each side of the sinus growing more rapidly than the portion bearing the water-gland and the water stomata.

### *Echium vulgare, L.*

*Fruit* breaking up into four (or fewer by abortion), one-celled, one-seeded nutlets which are ovoid-subconical, slightly incurved upwards, somewhat constricted above the horizontal attachment at the base, and again above the part occupied by the cotyledons, scabrid all over the surface or raised into little prominences, carinate along the upper part of the dorsal aspect, and along the whole length of the ventral suture, brown.

*Seed* ovoid, subcompressed dorsally, and slightly curved, owing to the curvature of the nutlet which it closely occupies; testa thin, membranous, yellowish; hilum above the middle on the ventral aspect; raphe and chalaza consisting of nerves, radiating from the hilum to the broad lower part of the seed; micropyle and radicle superior in the tip of the nutlet and some little distance above the hilum.

*Endosperm* absent.

*Embryo* slightly incurved owing to the shape of the seed and nutlet, large, and occupying the whole of the seed, yellowish; cotyledons broadly oblong, short, obtuse, entire, plano-convex, closely adpressed face to face; radicle occupying the conical tip of the

seed and conforming to it in shape, less than half the length of the cotyledons.

***Echium canescens, Presl.***

*Hypocotyl* erect, terete, hairy, 2.5–8 cm. long, light green or colourless.

*Cotyledons* broadly rotund or oblate, obtuse, shallowly emarginate, petiolate, pubescent, green, indistinctly trinerved or almost pinnatinerved; petiole broad, flat, shallowly channelled above.

*Stem* with the primary internodes undeveloped.

***Echium violaceum, L.***

*Hypocotyl* as in *E. canescens*, 1–1.2 cm. long.

*Cotyledons* broadly oval, entire, obtuse, with broad flat petioles, hairy, green, pinnatinerved as in the leaves.

*Stem* as in *E. canescens*.

*First leaves* simple, entire, radical, opposite, oblong-oval, obtuse, petiolate, exstipulate, hispid, green, pinnatinerved; succeeding ones alternate.

***Echium Decaisnei, Webb et Berth.***

*Hypocotyl* wiry, about 1.5 cm. long.

*Cotyledons* rotund, concave, shortly petiolate, about 8 mm. long, 4.5 mm. wide.

*Stem* erect or subflexuose, terete, and thickening upwards, woody, hispid with white, broad-based hairs; internodes numerous, short, 4–8 mm. long.

*Leaves* cauline, alternate, simple, entire, exstipulate, petiolate, numerous; limb lanceolate, obtuse or acute, penninerved, tapering to both ends, softly and densely hairy above with sunken nerves, pale green on both surfaces, densely hairy beneath with prominent midrib and lateral ascending nerves; petiole channelled above, convex beneath, dilated at the base and half amplexicaul, hispid, varying in length according to the size of the leaf which gradually increases successively from the base of the stem upwards.

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## CONVOLVULACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 865.

*Fruit and Seed.*—The ovary is superior and syncarpous, consisting usually of two carpels, rarely of three, five, or ten, and cohering so as to form as many cells as there are carpels. In some cases there are spurious septa interposed dividing the ovary into as many cells as there are ovules. The ovary is generally entire, but in rarer cases is divided into distinct erect lobes. The ovules are usually geminate in each cell, rarely one or four, sessile, basal, erect from the inner angle of each cell, anatropous or nearly so. The fruit is generally entire and globose, rarely oblong or conical, fleshy, baccate, pulpy and indehiscent, or capsular as in the typical genus, with hardened, crustaceous or membranous walls, indehiscent or dehiscing by two to four valves, rarely bursting irregularly or transversely operculate. In other cases the fruit is divided into two to many lobes, each piece constituting an indehiscent one-seeded nutlet; or it may be divided into as many cells as there are seeds when the latter are numerous. The seeds are as numerous as the ovules or fewer by abortion, basal from the inner angles of the cells and erect. When solitary they conform to the cavity of the fruit, but when there are two or more they become angled by mutual compressure. The testa is membranous or crustaceous, rarely fleshy and smooth, villous or woolly. Endosperm is present and fleshy or more usually forms a thin layer occupying the space between the various parts of the embryo. The latter is large and variously folded with thin and foliaceous cotyledons which are entire, emarginate, bifid or bipartite. More rarely the embryo is terete, curved and subspherical, or spiral with elongated semiterete or obsolete cotyledons. The radicle is inferior, directed towards the hilum and often more or less curved round the dorsal aspect of the seed. An exceptional case occurs in *Nephrophyllum* where the embryo is terete and much curved, with spiral cotyledons scarcely wider than the radicle. In the same category *Nolana*, *Alona*, and *Dolia* may be placed. The

species of *Cuscuta* have an embryo consisting of a terete spiral body with inconspicuous or obsolete cotyledons. A well-marked type of seed occurs in the numerous species of *Convolvulus* and *Ipomœa*, and as they correspond pretty closely they may be taken together. When more than two seeds reach maturity in a capsule, they are bluntly trigonous with the hilum basal, and facing the inner angle of the cell obliquely. The interior of the seeds is remarkable for an invagination of the tegmen along the ventral angle. The extent to which it is infolded varies greatly in different species; in all cases it is perhaps most marked at the apical end of the seed, and from thence it is continued towards the base. The seeds of some species are almost two-celled owing to the excessive development of this peculiar process, and a small opening is left just sufficient to permit of the embryo pushing half of each cotyledon into each of the halves of the seed. There is also a singular invagination of the micropyle close to the hilum, forming with the dorsal integument of the seed a tubular cavity in which the embryo arises, and which ultimately accommodates the radicle only. This is not so rare an occurrence as the first mentioned process, as we meet with it in species belonging to various Orders, although generally it is much less marked. Something like it occurs in *Acer* and *Æsculus* belonging to the Sapindaceæ. The embryo is large, and during development the cotyledons grow till they reach the apex of the seed or till they meet the invagination of the tegmen when the growth of the primary axis or midrib is stopped; or if it continues to grow, then the cotyledons become folded transversely upon themselves in the dorsal region of the seed. Sooner or later however the cotyledons become concave on the ventral aspect, and obliquely lateral lobes are developed so as to occupy the cells on each side of the invaginated tegmen. This causes the cotyledons to become emarginate, bifid or bipartite according to the length of the lateral lobes. When the latter attain great length they become very much folded, plicate or crumpled, giving the cotyledons the characteristics which mark them after germination. When the seeds are large and the cotyledons but little folded, the latter are but shallowly bifid or merely emarginate after germination; but when the seeds

are small and the cotyledons are much folded, they appear deeply bifid and bipartite after germination. The species of *Convolvulus* and *Ipomœa* observed may for convenience sake be divided into those which have merely emarginate, and those which have bifid, deeply bifid, and bipartite cotyledons. *Convolvulus Soldanella* may be given as a type having the cotyledons merely emarginate. The amount of the invagination of the tegmen is small ; the cotyledons undergo little folding in the seed, and they are seen to be five-nerved at the base even at a very early stage. The midrib forks a little way before reaching the sinus of the cotyledon, and this is what occurs in many, if not in all of the species coming under my notice. There is a more or less direct relation between the length of the midrib and the depth of the lobing, for the longer the lobes are the shorter the midrib which represents the real length of the axis of the cotyledon.

*Convolvulus sepium* agrees pretty closely with this type, as does also *C. tricolor*.

The cotyledons of *Ipomœa purpurea* are shallowly bifid, and the amount of folding is moderate in the seed ; but the infolding of the tegmen is considerable.

The seed of *Ipomœa Pes-capræ* is almost two-celled owing to the ingrowth of the tegmen on the ventral aspect, and the invagination of the micropyle is also considerable. The cotyledons are deeply bifid, but the amount of folding of the lateral lobes is moderate, and the length of the midrib is considerable owing to transverse folding on the dorsal aspect of the seed just after leaving the tube from the micropyle and before the lamina divides. This particular folding is due to growth in length of the lamina after the apical sinus comes in contact with the obstruction caused by the tegmen. The advantage or economy of the latter may be to prevent the lobes of the cotyledons from getting intricately confused with one another, thereby rendering exit from the seed during germination more difficult or even impossible. *I. Roxburghii* agrees pretty closely with this type. *I. Quamoclit* (fig. 539) also agrees with it as far as the invagination is concerned and the length of the lateral lobes of the cotyledons, but the latter are very much folded transversely so that

its axial length is considerable, and this is well seen after germination as well as before it. The seed is comparatively small.

*I. dasysperma* represents the fourth type in which the cotyledons are bipartite. The real length of the midrib, and therefore the lamina, is almost nil; but, on the contrary, we have an unusual development of the lateral lobes. The invagination of the micropyle and the tegmen is considerable. The radicle is long, in fact nearly equalling the length of the seed, bringing the apical sinus in contact with the prominent tegmen. The lamina is little or not at all transversely folded, but the folding is excessive in the long lateral lobes. The basal auricles are moreover well pronounced in this species. Two long lateral nerves traverse the lobes, and there is a third short one at the base. *Convolvulus Cneorum* might almost constitute a fifth type, so much does it differ from the last. The cotyledons are bipartite, in fact cut into the petiole, and they are folded transversely, but not to any great extent. The invagination of the tegmen is very slight, in fact almost obsolete. That of the micropyle is, however, normal. This divided state of the cotyledons may have arisen in an ancestral form having the inner coat of the seed strongly infolded as in the above cases, and the invagination may have become obsolete in more recent times, while the fission of the cotyledons has persisted. The fission would however favour or facilitate transverse folding, seeing that broad undivided cotyledons would have difficulty in folding into or adapting themselves to the peculiar shape of the seed. The seeds of this species are shortly and densely pubescent; those of *Ipomœa dasysperma* are silky, those of *I. Quamoclit* pubescent, of *I. Pes-capræ* densely so.

The seeds and embryos of *Nolana atriplicifolia* are built upon quite a different plan and strongly resemble those of a *Solanum*, a *Chenopodium*, or their allies. The ovule and seed are campylotropous. The embryo is terete and very much curved or circinate, passing round the periphery of the seed and covered merely by a very thin layer of endosperm, with a greater quantity of the latter in the middle of the seed. The cotyledons are incumbent, plano-convex, and lie in the narrow way of the seed which is angled but slightly compressed.

*Seedlings.*—The greater number of the seedlings observed are modelled on the same plan, but vary considerably in the depth of fission of the cotyledons, in the number of nerves radiating from the base of the lamina, and in size. Seedlings of the tribe Nolanæ have cotyledons resembling those of a *Solanum*. All those noticed may be conveniently divided into five or six groups according to the division of the cotyledons and their venation.

The first group may be represented by *Convolvulus Soldanella* which has broadly oblong or squarish, shallowly emarginate cotyledons with seven nerves radiating from the base. The hypocotyl is very short and the petioles of the cotyledons greatly elongated. The first two leaves are reniform-orbicular. The cotyledons of *C. sepium* are very similar but narrower and longer, with shorter petioles and a longer hypocotyl. The shoots proceeding from their axils are geotropic. The first two leaves are cordate and subhastate, acute and widely separated by the lengthening of the internodes. The first and second leaves of a seedling of this species curiously enough were almost the counterpart of the cotyledons, but were rather smaller and more deeply emarginate. Something similar is of frequent occurrence in *Ipomœa Pes-capræ*; in fact such a form is the most common one. The cotyledons of *Convolvulus tricolor* are obcordate or cuneate, bifid, trinerved at the base, and remarkably similar to those of *Brassica*, both in shape and venation. The first five leaves are spatulate, the sixth linear-oblong, and the seventh to the fourteenth inclusive, oblong. The cotyledons of *Convolvulus triflorus* are similar, but more deeply bifid. The two first leaves are oblong-ovate.

A third type is met with in *Ipomœa Pes-capræ* which has deeply bifid cotyledons, trinerved at the base as in the last case, while a pair of strong lateral nerves are given off from the midrib higher up, so that two strong lateral nerves traverse each lobe of the lamina. The primary leaves are very variable in different individual seedlings. In the one described the first one is oblong, and seven succeeding ones are oblong-obcordate, or shortly bifid as in the typical leaf of the adult plant which is not unlike the impression made by a goat's foot on the ground, hence the specific name. The

leaves of the adult plant in the Kew specimens are more polymorphic than those of the seedling ; they are broader than long, or suborbicular or oblong-emarginate, sometimes subcordate at the base, or they are ovate, or obovate-oblong. The cotyledons of *Ipomœa Nil* are also trinerved from the base, but they are rather less deeply divided, unequal in size and have wider lobes. The first three leaves are cordate, acuminate, and five-nerved from the base. *I. dissecta* (fig. 542) has also unequal, trinerved cotyledons, but they are more deeply auricled at the base, and a second pair of lateral veins arise a little above the base making them almost five-nerved. Their petioles are considerably elongated to compensate for the shortness of the hypocotyl above the soil. The first internode of the stem is but little developed, and the first leaf five-toothed and almost or quite rudimentary. The second leaf is five-lobed and several times larger, but yet very small. The third to the sixth inclusive are palmately five-nerved and -partite with rhomboid-lanceolate segments.

A fourth type is exhibited by those species having five to seven nerves proceeding from the base of the lamina. *Ipomœa hispida* (fig. 541) has cotyledons resembling those of *I. Nil* in outline and depth of division, but they are more nearly equal, and five-nerved at the base. The first two leaves are cordate, acute and seven-nerved at the base. The cotyledons of *I. Roxburghii* are larger, rather more deeply bifid, and seven-nerved at the base. The first leaf is cordate, acute, and the next two are similar, but angled at the sides or incipiently lobed. All are five- to seven-nerved at the base. The cotyledons of *Argyreia speciosa* are remarkably similar to those of *Ipomœa Roxburghii*. The first leaf is however cordate-acuminate, and the second cordate-acute. The hypocotyl of *Argyreia cuneata* is subterranean, fleshy, stout and inseparable from the upper part of the root. The cotyledons are faintly seven-nerved at the base, and have long, slender petioles partly buried in the soil. The internodes of the slender, flexuose stem are elongated. The first leaf is broadly oval and rounded at either end ; the following three are more elongated and proportionately narrower. The cotyledons of *Lettsomia aggregata* are divided more than half-

way to the base. The first two leaves are roundly ovate; the second spathulate; and the third obovate, and emarginate. A fifth very distinct group centres around *Ipomœa Quamoclit* (fig. 540) which has deeply bipartite cotyledons with linear, widely divaricate segments traversed by two nerves each. The real length of the lamina is from the apex of the petiole to the middle of the sinus, and is really very short. The lobes represent lateral growth after the cotyledons can no longer grow in length; they are very much folded transversely while still in the seed. The first two or more leaves are deeply pinnatisect with linear lobes appearing as if pinnate. *I. dasysperma* closely corresponds to this type, but the leaves are different from those of *I. Quamoclit*. The cotyledons of *I. palmata* are scarcely so deeply divided, and are rather irregularly four- to five-nerved at the base, with strongly ascending segments. The first three leaves are cordate, five- to seven-nerved at the base, and trifid at the apex, or they show a few more lateral teeth. The cotyledons of an unnamed, subshrubby, and apparently climbing species of *Convolvulus* are deeply bipartite with linear one-nerved segments. The first two leaves are lanceolate, while succeeding ones up to the ninth differ chiefly in their much greater length. An extreme limit of division is met with in *Convolvulus Cneorum*, an upright shrubby species with hoary and silky foliage. The cotyledons are cut or divided, not only to the base of the lamina, but into the petiole, giving rise to four diverging, one-nerved segments resembling as many cotyledons. The first four leaves are oblanceolate, and narrowed into a short petiole.

The simplest type of cotyledons in the Order as far as I have observed is that of the *Nolanæ*, whose peculiar characteristics have already been mentioned under seeds. Those of *Nolana atriplicifolia* (fig. 543) are lanceolate-oblong, fleshy, and indistinctly one-nerved. The first leaf is ovate and the four succeeding ones are more elliptic. The cotyledons of a *Nolana* from Santiago are narrowly spathulate, petiolate, one-nerved, and pubescent. The first seven or eight leaves exactly resemble the cotyledons in size, length, and hairiness.

***Argyreia cuneata*, Bot. Reg.**

*Primary root* perennial, fleshy, subglobose, smooth, and together with the hypocotyl forming a tuberous rootstock,

*Cotyledons* equal, with glabrous, green or reddish petioles, 4-5 cm. long, 1.5 mm. thick, with their basal ends 1 cm. or less below the surface of the ground on the broad collar of the hypocotyl, and surrounding six or more buds in the two axils; lamina 2.5 cm. long and as wide, bilobed, cordate at the base, obtuse at the apices, otherwise entire, palmatinerved, with a short midrib and two primary nerves meeting within the apex of each lobe, glabrous, thin, light green, rather persistent, and presenting a strange appearance through being partly buried.

*Stem* suberect, firm, terete, pubescent; 1st internode 4-6 cm. long, 1.5 mm. thick; 2nd and 3rd shorter.

*Leaves* simple, entire (at least in the seedling stage), cauline, alternate, exstipulate, petiolate, alternately incurvinerved, with the bases of the nerves decurrent on the midrib, smooth and deep green above, pubescent on the margin and covered with a silvery or silky tomentum beneath; petioles short, grooved on the upper side.

No. 1. Shortly petiolate, 3.5-4 cm. long, 2.5 cm. wide, oval, rounded at both ends, with entire, pubescent margin, sunk midrib and pinnate nerves, coriaceous, smooth and dark green above, woolly and paler beneath.

Nos. 2-4. Oval, slightly more tapered to both ends and larger, 6-7 cm. long, and 3 cm. wide.

***Argyreia speciosa*, Sweet.**

*Primary root* a long taproot with a large number of long, thick, much branched, white fibres.

*Hypocotyl* herbaceous, 6-8 cm. long, 2-2.5 mm. thick, terete, pubescent, dull green, purplish about the middle.

*Cotyledons* long-petioled, about 6 cm. long, 4-5 cm. wide, bilobed, deeply cordate at the base, obtuse at the apex, otherwise entire, with a short forked midrib and two strong primary nerves on each side, sunk and forming a very narrow ellipse in each lobe, quite glabrous, bright green above, paler beneath, thin, somewhat persistent; petioles semiterete, channelled.

*Stem* herbaceous, short, terete, tomentose; first few internodes about 5 mm. long, and 2-2.5 mm. thick.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, cordate, alternately incurvinerved, reticulated, glabrous and deep green



above, covered with a silky tomentum beneath, conduplicate in bud; petioles hairy, tomentose or woolly, subterete.

No. 1. With a tomentose subterete petiole 8·5 cm. long, and 1·5 mm. in thickness, and a cordate blade 4 cm. long, and 3 cm. wide with deep base and cuspidate apex, plane, pinnatinerved, with entire, pubescent margin, glabrous and bright green above, tomentose and paler beneath, not very thick; vernation conduplicate.

No. 2. Similar but larger.

*Lettsomia aggregata*, Roxb.

*Hypocotyl* erect, terete, glabrous, very short, about 6–8 mm. long.

*Cotyledons* bifid for more than half their length with diverging lobes, subcordate at the base, with the midrib very short and bifurcate some distance below the base of the sinus representing the true length of the cotyledon, and giving off two strong and one slender lateral nerve into the ascending and diverging lobes, petiolate, glabrous except the petiole, deep green above, paler beneath; lamina to the base of the sinus 1 cm. long, and the oblong-ovate lobes 1·5–1·6 cm. longer; width from tip to tip of the lobes 2·2 cm.; petiole subterete, channelled and downy above. 1·1–1·3 cm. long.

*Stem* stout, erect at first, ultimately twining, densely silky or hairy with adpressed hairs; 1st internode 5–8 mm. long; 2nd 3–5 mm.

*Leaves* simple, entire, cauline, alternate, exstipulate, petiolate, irregularly and alternately, ascendingly penninerved, with the ends of the nerves incurved and uniting one with another, subreticulate, densely silky hairy and subhoary on the under side, and pubescent above, deep green and shining with a silky margin; petioles subterete, channelled above, densely silky hairy.

Nos. 1 and 2. Rotund-ovate, obtuse, subcordate at the base.

No. 3. Spatulate, obtuse, entire, cuneate at the base.

Nos. 4 and 5. Obovate, emarginate, cuneate at the base.

*Ipomœa Pes-capræ*, Sweet.

*Ovary* of two to three carpels, two- to three-celled, four- to six-ovuled; ovules two in each cell, erect from the base of the inner angle of the cell, anatropous; micropyle inferior.

*Capsule* globose, two- to three-celled, four- to six-seeded, dehiscent by valves.

*Seed* obtusely trigonous, forming a segment of a sphere, convex

longitudinally and transversely on the back, blunter at the basal end, deep brown, almost black, densely pubescent; hilum inconspicuous; tegmen very much invaginated from the inner angle of the seed which is almost divided in two internally; micropyle also invaginated, containing at first the whole embryo, ultimately only the radicle.

*Endosperm* in the mature seed copious, clear or subtransparent, embedding the embryo, swelling up and mucilaginous in water.

*Embryo* large, curved, pale yellowish; cotyledons broad, deeply bifid, conduplicated and variously folded or plaited, one half of each lying on each side of the deep invagination of the tegmen; radicle large, curved, lying in the invagination of the micropyle towards or at the base of the dorsal aspect of the seed.

### Seedling.

*Hypocotyl* erect, terete, glabrous, about 1.6-2 cm. above the soil.

*Cotyledons* deeply bifid with diverging lobes, petiolate, thick and subcoriaceous and more or less shining, glabrous, deep green above, paler beneath, with a midrib reaching nearly to the sinus, and giving off from each side towards the base two strong nerves running nearly to the apex of the lateral lobes where they join; there is often present a third but more slender nerve from each side near the apex which runs along the inner edge of the lobes; lamina about 1 cm. long to the apex of the midrib, and about 2.2 cm. to the apex of the ascending lateral lobes, 2.6-2.8 cm. from tip to tip of the lobes; petiole semiterete, channelled above, glabrous, 6-8 mm. long.

*Stem* erect at first, terete or slightly furrowed from the base of the petioles downwards, flexuose or zigzag, dull brownish-green, glabrous; internodes often extremely irregular in the early stages of the plant; 1st one undeveloped or 5 mm. long; 2nd 2.5 mm.-2.1 cm.

*Leaves* simple, cauline, alternate, but often opposite, or irregularly fascicled in the younger state of the plant, exstipulate, petiolate, alternately and ascendingly penninerved, or oppositely nerved towards the base with numerous slender nerves branching and anastomosing with one another within the margin of the leaf, subcoriaceous, glabrous, more or less shining on both surfaces, deep green above, bright green beneath; petioles subterete, slightly channelled above, stout, somewhat decurrent on the stem, dull brownish-green, glabrous, tapering somewhat upwards.

Early leaves very variable in outline.

No. 1. In the specimen described, oblong, obtuse, slightly emarginate.

Nos. 2 and 3. Obovate-oblong, broadly emarginate with a tooth in the notch.

Nos. 4-7. Broadly obovate, or widely bifid, slightly cuneate at the base, with a tooth in the apical sinus.

The leaves on adult plants are very variable, as the following instances will show.

No. 1. Deeply obovate, and on the upper part of plant almost transverse, with oblong, obtuse, diverging lobes, having numerous ascending parallel veins—four from the base on each side and a few alternate ones upwards, with the midrib excurrent, much reticulated. The lower leaves were like the cotyledons.

No. 2. Rotund or oblong, emarginate, subcordate or rounded at the base, alternately penninerved with four contiguous pairs at the base; midrib slightly excurrent. Upper leaves broadly subovate, less cordate at the base. The midrib in both these plants was much in advance of the lamina in young unfolded leaves, but it gradually falls behind the lateral lobes as the leaf becomes ready to unfold.

No. 3. In another form the leaves were ovate or obovate-oblong, retuse, rounded or emarginate, and apiculate, irregularly alternately penninerved, more or less cuneate or wavy at the base, and having the midrib excurrent at the apex in all cases.

### *Ipomœa purpurea*, Lam.

*Ovary* surrounded at the base by an annular, hypogynous disc, of three carpels, three-celled, two ovules in each cell; ovules as in *I. Pes-capræ*.

*Capsule* globose, even and glabrous externally and internally, three-celled, two- to six-seeded, and containing the remains of the aborted ovules when less than six-seeded, tipped with the conical remains of the persistent style, dehiscing by three valves.

*Seeds* when six occupying the whole fruit, trigonous with the two outer angles acute, the inner one blunt, and the lateral faces flat and much broader than the dorsal aspect which is convex or rounded, both longitudinally and transversely, pale whitish, ultimately deep brown, rounded at the extreme base which projects a little beyond the hilum; hilum orbicular with a basal notch, brown before the seed is mature, seated on an oblique depression of the seed facing the inner angle of the cell. Where two seeds only occupy the fruit, they are ovoid or more or less hemispheric, occupying two cells of the ovary, while the third is nearly squeezed up close to the outer wall.

*Endosperm* plentiful, like a transparent jelly, occupying all the interior of the unoccupied space in the growing seed and surrounding the embryo, ultimately becoming dry and cartilaginous, occupying the space between the folds and wrinkles of the mature embryo, and still transparent where quite thin, mucilaginous and swelling up considerably when placed in water.

*Embryo* quite straight at first and lying in the conical hollow process near the hilum which forms a passage for the radicle to the micropyle; but later on as growth proceeds the cotyledons are projected beyond this process and commence to become concave towards the inner angle of the seed. They soon become doubled sharply over the end of the process, extending to the apex of the seed and both doubling over and abutting against the prominent ingrowth of the tegmen, become deeply bifid at the apex, more or less cordate at the base, and much wrinkled.

*Ipomœa Quamoclit*, L. (fig. 539).

*Ovary* of two carpels, two-celled or by the interposition of spurious septa four-celled; ovules as in *I. Pes-capræ*.

*Fruit* a capsule.

*Seed* trigonous, flat on the sides in contact with the others, rounded on the dorsal aspect both longitudinally and transversely, deep brown almost black, pubescent; hilum small, brown, facing the placenta obliquely; tegmen invaginated rather deeply but squeezed down by the growing embryo, so that in cross-section it resembles the letter T.

*Endosperm* in the mature seed forming a layer surrounding the embryo, subtransparent, becoming mucilaginous when placed in water.

*Embryo* large, conduplicate and curved, pale yellowish;

cotyledons large, foliaceous, bifid, cordate at the base, bent back at the end of the invagination of the micropyle and doubled in beneath it, then recurved upwards and proceeding to the apex of the seed; radicle subfusiform or cylindrical, obtuse, curved towards the

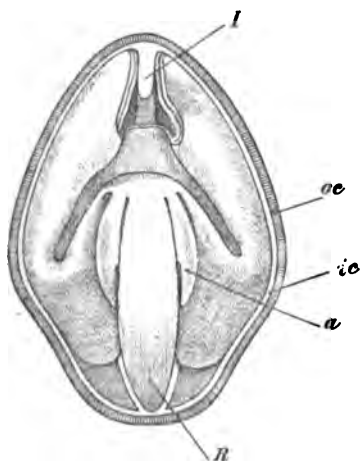


FIG. 539.—*Ipomœa Quamoclit*,  $\times 13$ .

Seed laid open, showing the dorsal face of the embryo *in situ*: *I*, invagination of the tegmen; *oc*, testa, and *ic*, tegmen of seed; *a*, auricles of cotyledons; *R*, radicle.

micropyle, following the outline of the basal and dorsal aspect of the seed.

**Seedling** (fig. 540).

*Primary root* a short, succulent taproot, with a few branched, colourless, fibrous lateral rootlets.

*Hypocotyl* herbaceous, about 6 cm. long, 1 mm. thick, two-furrowed, from the decurrent bases of the petioles of the cotyledons, glabrous, bright green.

*Cotyledons* very short but transversely linear, 3.5-5 cm. long from tip to tip, the broadest part about 4 mm. and the middle 3 mm. wide, cordate at the base, rather obtuse at the apex of each lobe, with a midrib 1 mm. long, giving off two strong lateral nerves on each side running parallel for some distance, and the upper one to the apex of the lobes, glabrous, pale green in the earlier stage, with undulate entire margin, thin, somewhat persistent.

*Stem* herbaceous, suberect, furrowed, glabrous, shining, light green; the first few internodes about 5 mm. long, 1 mm. thick.

*Leaves* uni- to bi-pinnatisect, deep green, glabrous, with slender linear segments.

No. 1. About 8.5 cm. long, 2 cm. wide, with a glabrous petiole 7.5 mm. long and .75 mm. thick, distinctly pinnatisect, with the lowest pair of segments shortly bipinnatisect, the other three pairs with the terminal segment narrowly linear, about 1.5 cm. long, 1.25-1.5 mm. wide, acuminate, glabrous, dark green, with sunk midrib.

No. 2. Similar, with five pairs of segments, most of which are bipinnatisect.

***Ipomœa hispida*, Roem. et Schult. (fig. 541).**

*Primary root* long, with a few branched white fibres.

*Hypocotyl* herbaceous, suberect, about 6 cm. long, 2 mm. thick, terete, glabrous, with decurrent lines from the base of the cotyledons, green with a light purplish hue.

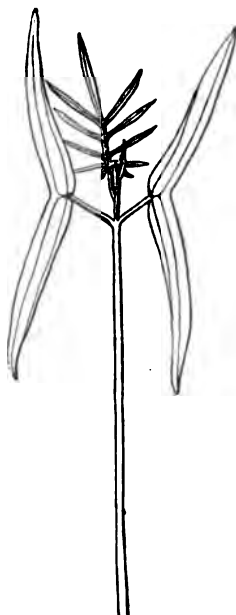


FIG. 540.—*Ipomœa Quamoclit*.  
Nat. size.

*Cotyledons* unequal, with petioles 3·5–4·5 cm. long, 2–8 cm. wide, quadrangular, bilobed, cordate at the base, rounded at the

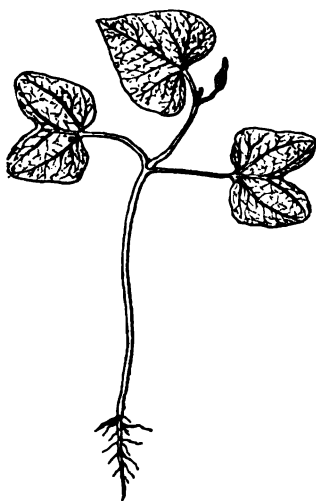


FIG. 541.—*Ipomoea hispida*.  
Half nat. size.

apex of each lobe, five-nerved at the base or, more correctly, giving off two strong primary nerves from each side of the midrib, the latter terminates in a small fork near the sinus, and the nerves become incurved and join near the apex of the lobes; strong secondary nerves are given off from the basal pair of primary ones; reticulated, quite glabrous, thin, yellowish-green above, paler beneath.

*Stem* herbaceous, twining, with long internodes about 1 mm. thick, terete, pubescent, with deflexed hairs, pale green.

*Leaves* alternately incurvinnerved or radiately at the base, reticulate, more or less pubescent, deep green above, paler beneath.

Nos. 1–8. Long-petioled, simple, 3·5–5 cm. long, cordate or subcordate, acute, entire, palmatinerved at the base, alternately nerved along the midrib, slightly pubescent, thin, bright green above, paler beneath; petiole slightly pubescent, pinkish.

### *Ipomoea Roxburghii*, Steud.

*Ovary* as in *I. purpurea*.

*Capsule* dehiscing by the three valves separating from the septa, almost invariably six-seeded; valves thin, rather brittle, pale brown.

*Seeds* trigonous, testa rather cartilaginous when dry, pale or dirty white, with the micropyle close to the round basal hilum, which faces obliquely the inner angle of the cell, somewhat marked by the crumpled cotyledons within.

*Endosperm* surrounding the large embryo, colourless while the seed is yet immature, afterwards cartilaginous when dry, thin and membranous at places where the cotyledons press upon it, and forming larger solid masses between the folds of the embryo.

*Embryo* large, green at first and becoming dirty white when mature and dry; cotyledons deeply bifid, cordate at the base, five-nerved, with the midrib becoming forked a little below the sinus,

one fork entering each lobe, superposed face to face, and then doubled longitudinally, the midrib and radicle following the curved back of the seed and the lateral margins of the cotyledons turned towards the inner angle, at first merely convex on the back and concave on the inner side, but ultimately becoming much crumpled transversely; radicle lying in a grooved process attached close to the micropyle on the dorsal aspect.

The sinus of the cotyledons seems to facilitate their doubling upon each other longitudinally, or may even be the effect of that act and the intrusion of the tegmen, for the lobes become longer and more developed as the seed progresses to maturity; the whole embryo which is very large conforms to the shape of the seed which with its fellow shares equally one cell of the ovary, while the six seeds fill the globose capsule.

### Seedling.

*Primary root* nearly vertical, a short taproot, with long, colourless, branched fibres.

*Hypocotyl* herbaceous, 6-8 cm. long, 2-2.5 mm. thick, terete, glabrous, seldom slightly pubescent, bright green.

*Cotyledons* seven-nerved at the base, 3.5-4.5 cm. long, 3.5-4 cm. wide, pubescent otherwise like those of *I. hispida*.

*Stem* herbaceous, suberect, terete, pubescent, the rather long hairs pointing downward; first few internodes about 1.5 cm. long, 1.5 mm. thick.

*Leaves*.—No. 1. Long-petioled, 5-6 cm. long, 3-4 cm. wide, cordate, acuminate, entire, radiately incurvinerved at the base, and alternately along the midrib, pubescent all over, thin, bright green above, paler beneath.

No. 2. Similar, but the apex cuspidate with one small lateral lobe.

No. 3. Similar, but slightly trilobed.

Ultimate leaves simple, cauline, alternate, exstipulate, petiolate, radiately incurvinerved at the base, and alternately upwards, reticulate, pubescent all over, membranous, bright green above, paler beneath; petioles rather slender, semiterete, channelled above, pubescent or hairy.

### *Ipomœa Nil*, Roth.

*Hypocotyl* suberect, herbaceous, 6-9 cm. long, 1.5-2 mm. thick, terete and reddish near base, ridged and pale green higher up, glabrous.

*Cotyledons* like those of *I. Roxburghii* in size and shape, but only trinerved, and sometimes asymmetrical.

*Stem* herbaceous, terete, glabrous, shining light green; 1st internode 1 cm. long, 1.5 mm. thick; 2nd 3 cm. long, 1 mm. thick; next longer and thinner.

*Leaves*.—No. 1. About 8 cm. long, 8 cm. wide (including the channelled glabrous petiole), cordate or subcordate, acuminate or cuspidate, entire, palmately incurvinerved, glabrous, thin, light green.

No. 2. Narrower in proportion to its length.

Ultimate leaves as in *I. Roxburghii*, but glabrous.

*Ipomœa dissecta*, Willd. (fig. 542).

*Hypocotyl* above ground very short, stout, fleshy, glabrous, pale or colourless.

*Cotyledons* foliaceous, very large, bifid for more than half their length, very broad transversely, with broadly oblong, obtuse, divaricate lobes, cordate at the base, glabrous, deep green, petiolate; venation consisting of a slender median nerve, bifurcate near its apex, and giving off a strong lateral nerve on each side near the



FIG. 542.—*Ipomœa dissecta*. Half nat. size.

base, and a stronger pair at the base of the lamina, and all four with ascending branches which again divide more or less; larger lamina 1.15 cm. long, 8.9 cm. wide (each lobe 2.7 cm. long); smaller lamina 1.1 cm. long, 8.6 cm. wide (each lobe 2.5 cm. long); petioles unequal, semiterete, channelled above, glabrous, purplish, the longer 5 cm. long, the shorter 4.1 cm. long.

*Stem* herbaceous, erect, soon twining, terete, glabrous, marked with small distant, papillose elevations, pale purplish; 1st inter-



node 8 mm. long ; 2nd hardly developed ; 3rd 1·8 cm. ; 4th 5 mm. ; 5th 6·2 cm.

*Leaves* palmately five- to seven-nerved and -lobed, glabrous, light green ; petioles slender, nearly terete, slightly channelled above, glabrous, pale green or tinted with purple.

No. 1. Very small, almost rudimentary, five-fid or -toothed.

No. 2. Much larger, but still very small, palmately five-lobed ; middle lobe much the largest ; basal smallest.

Nos. 3-6. Palmately five-sect with the basal and smallest lobes again divided on the posterior side into a more or less distinct lobe ; middle lobes rhomboid-lanceolate, acute, alternately penninerved and subreticulate, with a few irregular sized teeth, about the middle on each side—middle lobe largest, but similar to the rest in shape and margin.

*Ipomœa palmata*, Forsk.

*Hypocotyl* 2-3 cm. long, about 2 mm. thick, terete, smooth near the base, somewhat warty under the cotyledons, herbaceous, purplish-brown.

*Cotyledons* with glabrous, channelled, purplish-green petioles 1 cm. long, 1·25 mm. thick ; lamina deeply bifid, 2·5 cm. long, with a short midrib forking a little below the sinus, and giving off two, rarely three, primary nerves into each lobe, running nearly parallel to each other, without distinct union within the apex of the lobe, glabrous, thin, light green, paler beneath, somewhat persistent.

*Stem* short, terete, slightly scabrous or warty, herbaceous, purplish ; first few internodes 2 mm. long, 1·25 mm. thick.

*Leaves* radiately incurvinerved at the base, alternately nerved upwards, and reticulate, glabrous, membranous, light green above, paler beneath ; petioles rather long and slender, subterete.

No. 1. With channelled, glabrous, purplish petiole 3 cm. long, 1 mm. wide, and a broadly cordate blade, 2·5 cm. long, and as wide, acuminate trifid at the apex, obtusely angled near the cordate or subcordate base, with seven radiately incurving nerves, glabrous thin, yellowish-green above, paler beneath.

No. 2. Similar.

No. 3. Similar, but more palmatifid.

No. 4. Nearly palmatilobed, all the lobes being mucronate-acuminate.

*Convolvulus sepium*, L.

*Pistil* surrounded at the base by an annular disk ; ovary of two carpels, two-celled or by the early rupturing of the septum one-

celled, four-ovuled, sessile ; ovules erect, inserted at some distance from the centre of the fleshy placentas which occupy all the base of the ovary, anatropous, the raphe running along the inner angle and forming a stout ridge in the upper interior half of the ovary ; radicle next the hilum but on the dorsal aspect.

*Fruit* a capsule, globose, tipped by the persistent remains of the style, one-celled, two- to four-seeded, pale brown, brittle, glabrous externally, silky with adpressed pubescence internally.

*Seeds* trigonous when four are matured, with the lateral faces flat, or more or less shrunk or somewhat wrinkled, and the dorsal aspect longitudinally and transversely convex or rounded, obtusely and minutely tridentate at the base of the dorsal aspect, the radicle close to the middle tooth containing the micropyle, nearly white, ultimately brown, glabrous, albuminous ; hilum reniform, on the oblique basal scar with the convex side towards the inner angle.

When two seeds mature, even if in the different though undivided compartments of the ovary, they share the space and become nearly or quite hemispheric.

When one seed only is produced it becomes ovoid or subglobose and variously but obtusely angled.

*Endosperm* plentiful, of a clear jelly-like consistency and mucilaginous when the seed is in a growing state and completely surrounding the embryo. As the seed matures it diminishes, adapting itself to the various wrinkles and folds of the embryo, at the same time becoming hard and horny, but preserving a clear colour where still thin and membranous.

*Embryo* straight at first with flat cotyledons which ultimately become very large and variously wrinkled, adapting themselves to the internal construction of the seed. When the embryo is only 2 mm. long and 1.5 mm. broad, it is nearly, if not quite, straight and flat ; the cotyledons are rotund, entire, and trinerved, and the whole embryo is embedded in jelly-like endosperm and rests in an invagination of the micropyle, which increases in size with the embryo. The cotyledons project beyond this and become at first concave towards the inner angle of the seed ; they soon become much concave and slightly emarginate, doubling sharply over the point of the supporting process, and down behind it where the liquid endosperm offers no resistance. The cotyledons up to this stage are green. As they attain full size they become much wrinkled, and pale yellowish or dirty white. They have previous to this ultimate stage grown to the full length of the seed, and the shallow notch in the cotyledons abuts against a ridge at the apex of the seed formed by

the invaginated tegmen extending some way down the interior of the dorsal aspect of the seed where it becomes shallow and extends to the hilum. Hence the notch in the cotyledons is caused by their growing at the sides after their apex has reached this ridge.

### Seedling.

*Primary root* elongated, tapering, with numerous lateral branching fibres.

*Hypocotyl* erect, terete, glabrous, green or purplish, stout, 7-15 mm. long.

*Cotyledons* large, foliaceous, broadly oblong, truncate and shallowly emarginate above, truncate or abruptly cuneate at the base where they are five-nerved, alternately nerved upwards; nerves strong, forking, the midrib generally though not always proceeding to the tip, sometimes forking a little way below it, light green, glabrous; lamina 2-2.8 cm. long, 1.9-2.65 cm. wide; petiole semiterete, channelled above, 2 to 2.5 cm. long.

*Stem* herbaceous, at first erect, afterwards twining from right to left or against the sun, above the first or second true leaf, terete, glabrous, twisted after commencing to twine; internodes very variable, 1st 3.4-6.5 cm. long; 2nd almost undeveloped to 3 cm.; the rest longer.

The first two branches originating in the axils of the cotyledons are geotropic, deep red, and resolve themselves into underground rhizomes or creeping stems, with small scale-like leaves. If the main axis should by any accident be broken off, the branches from the cotyledons assume the appearance and characters of the primary stem, and perform the same functions.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, glabrous, light green, five-nerved at the base, alternately nerved upwards with somewhat incurved, anastomosing nerves; petioles semiterete, glabrous, channelled above, frequently twisted at the base to bring the blade of the leaf to the light.

No. 1. Cordate-subhastate, cuspidately acute, with the lower pair of lateral nerves running into the obtuse angles.

No. 2. Cordate, elongated, cuspidately acute or having an odd, obtuse angle on one side.

Nos. 3 and 4. Cordate, elongated, cuspidately acute.

These characters are liable to variation, and sometimes all the early leaves are simply elongated-cordate. In one specimen noted the first two leaves were exactly like the cotyledons, but smaller and rather more deeply emarginate.

Ultimate leaves hastate or sagittate, always with a deep basal

sinus, obtuse or acute with the basal lobes frequently angled or obtusely dentate.

***Convolvulus Soldanella, L.***

Fruit, seeds, and embryo similar to those of *C. sepium*; seeds a deep, dull, purplish-black colour.

**Seedling.**

*Hypocotyl* short, subterranean, gradually and indistinguishably tapering into the root.

*Cotyledons* very similar to those of *C. sepium*, but rather wider and with longer petioles.

*Stem* herbaceous, erect, terete, marked with two raised, somewhat muricate lines running down from the base of each leaf, one on each side, green, heavily mottled with purple in the young stage, glabrous, ultimately procumbent, trailing or slightly twining, considerably twisted, pale green and mottled with pale purple; internodes variable; 1st 8-8 mm. long; 2nd 3.5-4.5 mm.; 3rd 4.5-10 mm. Ultimate ones 2-3 cm.

*Leaves* exstipulate (or adult ones with stipule-like excrescences at the base of the petiole which are constant), trinerved from the base, each nerve branching considerably on the lamina of the leaf; petiole as in *C. sepium*.

Nos. 1 and 2. Reniform-orbicular, minutely emarginate, otherwise entire or rarely incipiently angled at the sides towards the base, cuneate in the basal sinus, deep green, shining.

Ultimate leaves reniform, shortly cuspidate, shallowly and obtusely angled at the ends of the principal nerves and shallowly crenate between, cuneate in the basal sinus, the three primary nerves much branched, giving rise to reticulate venation.

***Convolvulus tricolor, L.***

*Capsule* two-celled, one- to four-seeded, pale brown, brittle, dehiscent by the separation of the valves from the septum.

*Seed* where four occupy the capsule obtusely trigonous, forming the fourth part of a sphere, equal at the base, muricate or covered with little elevations on all sides, pale whitish, ultimately brown; hilum oblong-subreniform, small, seated about the centre of the small horizontal depression at the base of the seed, with the slightly convex side to the inner angle.

*Endosperm* thin and membranous where in close contact with the folds of the embryo, but forming masses in the unoccupied spaces, swelling up and becoming mucilaginous in water.

*Embryo* straight in the early stages and lying in a truncate, hollow invagination of the micropyle, becoming curved at an early period, after the cotyledons project beyond the hollow process, then becoming concave on the side towards the axis of the ovary; as growth proceeds it reaches the apex of the seed and then becomes sharply doubled transversely over the end of the supporting process where there is no resistance. After this it extends to the inner angle of the seed with its edges on each side of the slightly prominent invagination of the tegmen. The cotyledons become transversely oval and slightly emarginate at a very early age, a shape which they retain to the last, and are deep green from the time they become visible till mature, when they become pale yellow; radicle in the mature embryo at right angles to the midrib of the cotyledons.

*Convolvulus tricolor*, L., var. *robustus unicaulis*.

*Primary root* long, flexuose, with numerous lateral rootlets, annual.

*Hypocotyl* erect, terete, thickened under the cotyledons, glabrous, a deep blood-purple.

*Cotyledons* obcordate, suddenly tapering at the base, trinerved, subcoriaceous, glabrous except the petiole, which is channelled above and slightly pubescent on the margins of the channels, and dull blood-purple; lamina green, 1.45 cm. long, 1.55 cm. wide; petiole 1.5 cm. long.

*Stem* herbaceous, annual, erect, terete, pubescent, deep blood-purple at the base and green upwards; 1st internode 6 mm. long; 2nd undeveloped; 3rd 6.5 mm.; 4th 4.5 mm.; 5th 9 mm.; 6th 7.5 mm.; 7th 9 mm.; 8th 9 mm.

*Leaves* simple, entire, cauline, alternate (first two opposite or subopposite), exstipulate, sessile, sparsely villous when young, ultimately glabrous or minutely pubescent, with a median nerve and a few lateral, alternate, ascending nerves.

Nos. 1 and 2. Opposite or subopposite, spatulate, rounded at the end and tapered to a long, narrow, petiole-like base.

Nos. 3-5. Spathulate, obtuse, narrowed to the base.

No. 6. Linear-oblong, cuspidate, not much narrowed to the base.

No. 7. Oblong, acuminate, acute, with a broad base.

No. 8. Oblong, cuspidate, broadest about the middle.

Nos. 9 and 10. Broadly oblong, obtuse, apiculate, broad and subcordate at the base.

Nos. 11-14 inclusive. Oblong, acute, rounded at the base.

***Convolvulus Cneorum, L.***

*Ovary* of two carpels, two-celled, four-ovuled ; ovules ascending or erect, anatropous ; micropyle inferior.

*Capsule* one-celled by the early rupturing of the septa, ovoid or subglobose, membranous, dehiscing irregularly, one- to two-seeded.

*Seed* ovoid, somewhat pointed, angled, slightly prolonged and truncate on the posterior basal side, deep brown, shortly and densely pubescent ; hilum small, round, facing the basal placenta obliquely ; chalaza inconspicuous ; tegmen thin, membranous, white.

*Endosperm* clear, subtransparent, surrounding the embryo and filling up the interstices, mucilaginous and swelling up when placed in water.

*Embryo* large, twice folded, or once folded when the upper third is reversed upon the middle one, embedded in the endosperm, pale yellow ; cotyledons shortly petiolate, bipartite or cut into the petiole, with oblong, obtuse, one-nerved lobes ; one lobe of each cotyledon lies on either side of the median line of the seed ; radicle large, curved, tapering to an obtuse point, incumbent, lying in an ovate process of the micropyle.

**Seedling.**

*Hypocotyl* erect, terete, glabrous, colourless, about 1.85 cm. above soil.

*Cotyledons* bisected to the petiole with oblong, obtuse, diverging segments, each with a central midrib, uniting with one another in the common petiole at or above its middle, alternately penninerved, narrowed at the base to a secondary petiole, glabrous, pale, somewhat greyish-green above and covered with minute scales, pale, but clearer green beneath and minutely scaly ; lamina 1.3–1.45 cm. long, 4.5–5 mm. wide ; primary petiole semiterete, channelled above, glabrous, pale green, 3.5–4 mm. long ; secondary petiole 1–1.5 mm. long.

*Stem* becoming shrubby, erect, terete, thinly hairy in the seedling, pale green ; 1st internode 9.5 mm. long ; 2nd 3.75 mm.

*Leaves* simple, entire, cauline, alternate, exstipulate, petiolate, alternately penninerved ; nerves incurving, hoary and silky on both surfaces with adpressed hairs ; petioles semiterete, short, channelled above, covered with adpressed silky hairs.

Nos. 1–4. Oblanceolate, cuspidate, narrowed into the petiole.

***Nolana atriplicifolia, Don.***

*Ovary* of five, rarely ten, carpels, one- to four-ovuled ; ovules campylotropous ; micropyle inferior.

*Capsule* few-seeded.

*Seed* variously angled and shaped, rather compressed laterally, 3-3.5 mm. in diameter; testa slightly rugose, thick, almost corky; hilum rather conspicuous.

*Endosperm* fleshy, copious, white.

*Embryo* curved or rounded on itself, embedded in endosperm; cotyledons long, linear, circinate curved, obtuse, plano-convex, lying the narrow way of the seed with their faces to the axis, not much wider than the radicle; radicle obtuse, terete, incumbent on and about as long as the cotyledons.

*Nolana atriplicifolia* var. *subcærulea* (fig. 543).

*Primary root* long, tapering downwards, stout, with slender lateral rootlets.

*Hypocotyl* very short, suddenly tapered into and indistinguishable from the root, colourless.

*Cotyledons* lanceolate-oblong, obtuse, with a very indistinct midrib, flattened above and convex beneath, fleshy, tapered to a short petiole, glabrous, light opaque green, fading to yellow with age; lamina 7.5-10.5 mm. long, 2.5-3.25 mm. wide; petiole .5-1 mm. long, connate at the base round the plumule.

*Stem* developed when about to flower; primary internodes undeveloped.

*Leaves* simple, entire, radical and cauline, alternate, exstipulate, petiolate, fleshy, flat or convex above, glabrous except towards base of the petiole, indistinctly alternately incurvinerved, venation best seen on the under side of young leaves, light yellowish-green above, paler beneath; petioles semiterete, channelled or shallowly grooved above, dilated towards the base and thinly hairy.

Nos. 1 and 2. Ovate, obtuse, somewhat convex above.

Nos. 2-5 inclusive. Subelliptic, obtuse, flattened above or slightly convex.

*Nolana* sp.

*Hypocotyl* erect, terete, glandular-pubescent, pale green, 1.5-2 cm. long.

II.

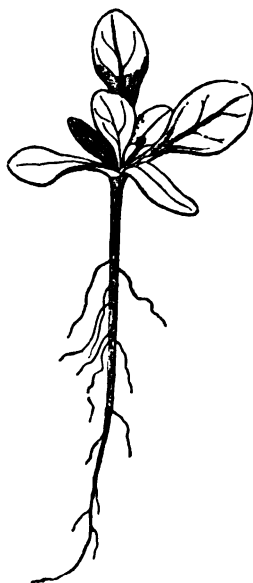


FIG. 543.—*Nolana atriplicifolia* var. *subcærulea*.  
Nat. size.

*Cotyledons* narrowly spathulate, obtuse, glandular-pubescent, petiolate, subfleshy with an indistinct midrib, but no other nerves discernible, pale green, 1.6–1.9 cm. long including petiole, 3–3.5 mm. at the widest, similar to the primary leaves in every respect.

*Stem* erect, terete, herbaceous, ultimately shrubby, glandular-pubescent, pale green; primary internodes irregular, short.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, glandular-pubescent on both surfaces, subfleshy, pale green, with a midrib slightly sunk on the upper, and slightly prominent on the under surface, no other nerves discernible in the seedling stage, tapering into the petiole; petiole slightly channelled above, similar to the tissues of the leaf and similarly pubescent.

Nos. 1–17 inclusive. Narrowly spathulate, obtuse, entire, somewhat convex above and concave beneath, narrowed insensibly into the petiole.

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## SOLANACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 882.

*Fruit and Seed.*—The ovary is superior and two- or rarely three- to five-celled or four-celled by the development of spurious septa as in *Datura Stramonium* and others. The ovules are nearly always very numerous in each cell and attached to large peltate, or massive, solid, and fleshy axile placentas; they are also arranged in many series, and anatropous or sometimes amphitropous. Sometimes but rarely they are few, and very rarely solitary and fixed to the middle of the septa. The fruit is very often baccate, but is sometimes capsular, dehiscent circumscissely above the middle, or septicidally by two entire or bifid valves, leaving the placentas naked or cohering more or less with them. The seeds are mostly very numerous, with a membranous or crustaceous rugose or sometimes almost muricate testa; more rarely the testa is dilated into a wing surrounding the seed. A fleshy endosperm is present. The embryo is most frequently narrow, terete, strongly incurved, circular, or subspiral with cotyledons shorter than the radicle and in the more typical members of the Order not broader than it. In the *Cestrinæ* and the *Salpiglossidæ* the embryo is straighter, more central, and the cotyledons are often con-



siderably broader than the radicle. The radicle is generally close to the hilum. Some abnormal forms occur in the Order such as *Nicandra* and *Jaborosa*, as well as a few species and varieties belonging to other genera in which the ovary is three- to five-celled.

The two cells of the ovary are subdivided by the development of spurious septa in *Datura*, *Solandra*, and *Grabowskia*. The ovules are few in the last named genus and solitary in each cell of *Sclerophylax*, the latter being very anomalous in other respects, including the one- to two-seeded indehiscent fruit. The fleshy fruit of *Grabowskia* contains four woody pieces, each with one or two seeds. The capsules of *Hyoscyamus*, *Scopolia* and *Physochlaina* dehisce by an operculum. The fruits of some species of *Cestrum*, *Lycium* and *Retzia* are baccate and contain but few seeds or sometimes only one.

Two leading types of embryo are met with in the Order, namely, the subperipheral and more or less curved form, and a nearly straight flat embryo. A very common type is that represented by *Datura Stramonium* which has a terete embryo surrounding the periphery, but slightly within the endosperm of the flattened and reniform-orbicular seed. The semiterete cotyledons lie in the narrow plane of the seed which has a crustaceous testa. The hilum is situated in a deep cavity at the base of the seed. A transverse section shows the radicle and the cotyledons, the latter being cut through once or twice. A similar section of *Solanum Dulcamara* often shows the radicle cut through twice, and the short cotyledons only once. *S. capsicastrum* has an embryo considerably less curved, and the reniform and much compressed seed is girt by a woody mass on each edge. The flattened and reniform seed of *Datura Stramonium* may be compared with that of *Barleria repens* which has a large embryo with flattened orbicular cotyledons. The seed of the latter is orbicular, exalbuminous, and belongs to the *Acanthaceæ*. The seed of *Nicotiana rustica* is subreniform, and contains an embryo much less curved and forming only a semicircle.

The seed of *Cestrum fasciculatum* is amphitropous and dorsally much compressed. It contains a nearly straight

embryo with broadly ovate or subtriangular cotyledons. The terete radicle is slender and nearly twice as long as the cotyledons. The seed is attached ventrally to the placenta, and is more or less angled by mutual pressure with its fellows.

*Seedlings.*—The cotyledons are all of simple types and vary from subulate to linear, lanceolate, oblong, ovate, oval, and sub-orbicular. Species with emarginate cotyledons occur only where the latter are short and broad. The commonest type is lanceolate or narrowly oblong in accordance with their shape while yet in the seed.

One of the most typical forms is represented by *Lycopersicum esculentum* and *Solanum Fontanesianum* (fig. 544) which have lanceolate cotyledons. In the first named the cotyledons are hairy and one-nerved. In *S. Fontanesianum* they are glabrous with the exception of the petiole. The cotyledons of *S. Jacquinii* are more broadly lanceolate, indistinctly penninerved and finely pubescent. A species of *Capsicum* (fig. 545) is notable for the great size of its cotyledons, the length of the petiole, and the three pairs of nerves in the lamina ascending at an acute angle.

A slightly different form is met with in *Solanum Dulcamara* which has narrowly oblong, obtuse, one-nerved cotyledons. The widest cotyledons noticed are those of *Solanum quitoense*, which are broadly ovate and glandular-hairy on both surfaces.

The cotyledons of species belonging to the tribes Cestrinæ and Salpiglossidæ present a number of short, wide, and often emarginate cotyledons more characteristic of the Scrophularinæ than of the Solanaceæ proper, and owe their shape in great part to that of the seed. Where emarginate cotyledons occur they probably owe this modification to growth. *Browallia elata* (fig. 549) presents a type very unlike the rest of the Order. The cotyledons are oblate, that is, transversely oblong. They are also very small, one-nerved and distinctly emarginate. The first two leaves are small, oblong-ovate, deeply and bluntly serrate.

*Lycopersicum esculentum*, *Miller*.

*Primary root* tapering vertically downwards or diverging at an obtuse angle, giving off lateral adventitious rootlets.

*Hypocotyl* variable in length, 8 cm. or more, 1·5 mm. thick, terete, coarsely pubescent or hairy.

*Cotyledons* oblanceolate-linear, obtuse, entire, tapering towards the broad clasping base, 3·3 cm. long, 3–4 mm. wide, hairy.

*Stem* terete, coarsely hairy, about 1 mm. thick when showing two leaves above the cotyledons, but rapidly becoming much stouter; 1st internode 8 mm. long; 2nd almost suppressed, thus bringing the first two leaves nearly, but not quite, opposite; 3rd and 4th gradually longer.

*Leaves* cauline, alternate, exstipulate, petiolate, more or less pinnatisect, coarsely hairy and glandular-rugose.

No. 1. Unequal at the base, consisting of a large terminal unequally trilobed segment, and a small, oval, entire, obtuse lateral one.

No. 2. More perfect; terminal segment ovate, trilobed; lobes obtuse; basal pair small, lanceolate.

No. 3. Pinnately trisect; terminal segment triangularly ovate, shallowly trilobed, subcordate at the base; lateral segments narrowly ovate, obtuse, cordate at the base and falcately curved, entire.

No. 4. Pinnately four-sected; the terminal and the lowermost segments solitary.

No. 5. Pinnately five-sected; basal pair of segments small, ovate, entire, obtuse, cordate at the base; middle pair ovate, elongate, entire, obtuse, cordate at the base; terminal segment ovate-elongate, obtuse, shallowly lobed, somewhat twisted towards the top.

No. 6. Similar; the two lateral pairs ovate, obtuse, entire, unequally subcordate at the base; terminal one much larger, ovate, elongated, obtuse, shallowly lobed and somewhat involute at the margins longitudinally on the upper entire part; petiole terete, stout, furrowed somewhat on the upper side.

Stem, leaves and petioles are covered with two kinds of hairs at least in the younger state; longer hairs coarse and non-glandular; shorter hairs fine and tipped with glands.

Ultimate leaves irregularly and interruptedly pinnatisect; segments stalked, not articulate (therefore not pinnate), obtuse or subacute, opposite; lowest pair usually small, ovate, entire; second pair oblong, ovate, pinnatifid or coarsely dentate; third pair very small, ovate, scarcely opposite; fourth pair oblong-ovate, shallowly lobed, very unequal at the base; fifth pair very small, oval, alternate; terminal leaflet or segment oblong, pinnatifid.

The adult leaves, moreover, are extremely variable in size in the

division of the lamina as well as its component parts. This variation depends greatly on the luxuriance of the plant or otherwise, brought about by cultivation.

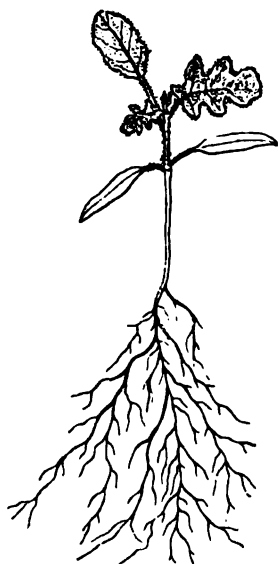


FIG. 544.  
*Solanum Fontanesianum*.  
Two-thirds nat. size.

*Solanum Fontanesianum*, *Dun.* (fig. 544).

*Primary root* slender, oblique, colourless, with many slender, branched, fibrous, lateral rootlets.

*Hypocotyl* succulent, 2 cm. long, 1 mm. thick, terete, glabrous, colourless, with the petioles of cotyledons forming a kind of sheath around the base of the stem.

*Cotyledons* stalked, 1.5–2 cm. long, 4 mm. wide, lanceolate, tapering to the base, acute at the apex, glabrous except the pubescent petiole, with sunk midrib, succulent although thin, yellowish-green, not very persistent.

*Stem* succulent, terete, ciliate, colourless; 1st internode 5 mm. long, 1 mm. thick.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, alternately and ascendingly penninerved, pubescent, hairy, setose and bristly or subspiny, membranous, pale green; petiole semiterete, channelled above, hirsute.

No. 1. 2.5 cm. long, 7.5 mm. wide, oblong, oblique and cuneate at the base, rounded at the apex, with a sinuate margin, alternately penninerved, hirsute, pubescent, thin, light green; petiole 1.25 cm., semiterete, shallowly channelled, pubescent or ciliate.

Nos. 2 and 3. Similar, but scalloped or repandly pinnatifid, and showing a few spines on the midrib and primary nerves.

#### *Solanum Dulcamara*, *L.*

*Primary root* tapering finely, flexuose, with a few similar rootlets.

*Hypocotyl* as in last species, but dull green, ultimately woody.

*Cotyledons* oblong, obtuse, tapering to the base, glabrous; lamina 1.4 cm. long, 5.5 mm. wide; petiole somewhat grooved above, 5 mm. long.

*Stem* erect at first, ultimately decumbent or trailing, flexuose,

succulent, ultimately woody, dull green, pubescent; 1st internode 4 mm. long; 2nd 5 mm.; 3rd 5 mm.; 4th 6 mm.

*Leaves* thinly pubescent and ciliate, ultimately glabrescent except at the margin, where the hairs are more persistent; petioles channelled on the upper side tapering downwards from their point of insertion.

No. 1. Ovate, entire, obtuse, cuneate at the base.

No. 2. Cordate-ovate, obtuse, entire, having ascending incurved nerves.

No. 3. Cordate-ovate, slightly unequal at the base, obtuse.

No. 4. Ovate, acute, unequal at the base.

Ultimate leaves more or less pubescent but variable, cordate-ovate, subacuminate, obtuse, equal or unequal at the base; other forms are triangular-ovate, acuminate, obtuse, deeply pinnatifid at the base with two to three basal lobes, and a large, ovate, acuminate, terminal lobe; lateral lobes obliquely oblong, or ovate, obtuse, binerved.

### *Solanum giganteum, Jacq.*

*Hypocotyl* finely pubescent, light green or colourless.

*Cotyledons* ovate-lanceolate, acute, entire, ciliate, shortly petiolate, minutely pubescent, light green, indistinctly pinnatinerved like the leaves.

*Stem* erect, terete, herbaceous, pubescent, light green; 1st internode 2-4 mm. long.

*First leaves* ovate-oblong, acute or subobtuse, ciliate, sprinkled over with a few short hairs, light green, distinctly pinnatinerved.

### *Solanum Jacquinii, Willd.*

*Hypocotyl* as in *S. giganteum*, but 3-4 cm. long.

*Cotyledons* lanceolate, acute, unequal, petiolate, minutely pubescent with distinct midrib and indistinct lateral nerves.

*Stem* as in *S. giganteum*; 1st internode 4-5 mm. long.

*First leaves* lanceolate-ovate, serrate, acute, pubescent, light green, distinctly pinnatinerved. Subsequently they become lyrate.

### *Solanum quitense, Lam.*

*Primary root* comparatively short, tapering downwards and branched.

*Hypocotyl* glandular-pubescent or hairy, 1.8-1.5 cm. long.

*Cotyledons* broadly ovate, acute or subacute, glandular-hairy on both surfaces, with a distinct midrib; lamina 1-1.2 cm. long, 6-8 mm. wide; petioles channelled above, 4 mm. long.

*Stem* with the primary internodes undeveloped.

*Leaves* radical as well as cauline, densely glandular-hairy, incurvinnerved; petiole rather deeply channelled above.

No. 1. Broadly ovate, obtuse, entire.

No. 2. Cordate-ovate, obsoletely angled at the sides.

**Capsicum sp.** (fig. 545).

*Hypocotyl* erect, terete, thinly pubescent or nearly glabrous, pale green, 2-2.5 cm. above the soil.

*Cotyledons* oblong-lanceolate, acute, tapering considerably to both ends, foliaceous, subfleshy, with a few alternate ascending nerves, hardly discernible except on the under side, glabrous or very thinly pubescent, deep shining green above, pale beneath, 6-8.4 cm. long including the petiole, 5-7.5 mm. at the widest part; petioles long, semiterete, slightly channelled above, pale green, thinly glandular-pubescent.

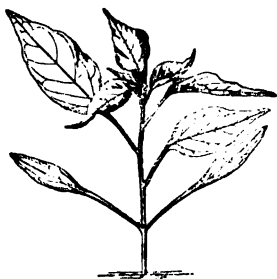


FIG. 545.—*Capsicum* sp.  
One-fourth nat. size.

*Stem* erect, terete, striate, thinly pubescent with upcurved hairs, pale or light green; 1st internode 2-2.4 cm. long; 2nd 1.4-1.8 cm.; 3rd 1.8-1.5 cm.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, alternately, irregularly, ascendingly incurvinnerved, faintly reticulate, thinly pubescent on the nerves or glabrous, thinly interspersed with sessile glands when very young, deep shining green above, paler beneath and shining, suddenly narrowed to a cuneate base, or even decurrent on the petiole; petiole semiterete, shallowly channelled on either side of a central obtuse ridge, slightly winged at the upper end, pale green, thinly glandular-pubescent.

No. 1. Narrowly ovate, acuminate, obtuse, minutely, erosely and irregularly dentate at the margin.

No. 2. Larger, similar or oblong-ovate, acuminate, obtuse, erosely dentate like the first.

Nos. 3-7. Lanceolate, acuminate, obtuse or subacute, often rather irregular in outline, pubescent at the margin, almost or quite entire.

**Lycium afrum, L.**

*Hypocotyl* erect, terete, glabrous, 2-3 cm. long, light green or colourless.

*Cotyledons* thick, fleshy, linear-oblong, obtuse, tapering to the base, entire, glabrous, one-nerved, with young buds in their axils.

*Stem* erect, terete, glabrous, herbaceous, ultimately woody, internodes from 7·5–10 mm. long.

*First leaves* simple, entire, alternate, fleshy, oval, obtuse, petiolate, glabrous, one-nerved like the cotyledons, exstipulate, but some of them have a small stipule-like leaf at the base.

*Datura gigantea*, Hort. (fig. 546).

*Primary root* long, tapering, colourless, giving off a few adventitious rootlets, annual.

*Hypocotyl* herbaceous, succulent, erect, terete, glabrous, purple, and shining, about 8 cm. long, 2·4 cm. thick, when the plant has developed two or three leaves.

*Cotyledons* linear, obtuse, petiolate, glabrous, succulent, one-nerved; lamina 2·5 cm. long, 4 mm. wide; petiole 7·5 mm. long.

*Stem* herbaceous, succulent, erect, terete, glandular when young, ultimately glabrescent, green, stained with purple; 1st internode 9 mm. long; 2nd 2 mm.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, hairy on both surfaces when young, glabrescent when mature, alternately penninerved, deep green stained with purple, at least in the young state.

No. 1. Ovate-oblong, obtuse, entire, cuneate at the base.

No. 2. Triangular-ovate, subacute, subtruncate at the base, with two angles or blunt teeth on each side, foreshadowing lobing.

No. 3. Oblong, subacute, constricted near the base, trilobulate on each side.

Ultimate leaves large, triangular-cordate, subacuminate, obliquely pointed, lobulate and coarsely dentate, slightly unequal and trinerved at the base, with strong, branching, alternate nerves above, reticulate, pubescent on both surfaces; petiole terete with a shallow groove above the base on the upper side.



FIG. 546.—*Datura gigantea*  
Half nat. size.

**Cestrum Parqui, L'Herit. (fig. 547).**

*Primary root* long, stout, with fine lateral rootlets.

*Hypocotyl* erect, terete, thinly pubescent, pale green.

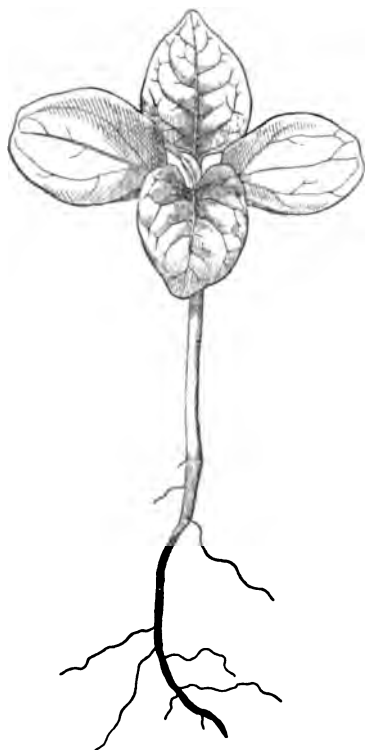


FIG. 547.—*Cestrum Parqui*. Nat size.

*Cotyledons* broadly oval, obtuse, with a broad shallow sinus at the apex, petiolate, obscurely, alternately incurvinerved and reticulate, with the midrib and two laterals proceeding from above the base much stronger than the rest, glabrous except on the midrib beneath, membranous, pale green; lamina 1.0–2.1 cm. long, and 1.5–1.6 cm. wide; petiole semiterete, flattened above, pubescent.

*Stem* erect, terete, pubescent; 1st internode 4.5 mm. long.

*Leaves* simple, entire, cauline, alternate, exstipulate, petiolate, glabrous except the midrib beneath and the petiole which are somewhat pubescent, alternately incurvinerved and reticulate; petiole semiterete, grooved above, short in the seedling stage.

Nos. 1 and 2. Cordate, cuspidate, obtuse, smaller than the cotyledons.

**Cestrum elegans, Schlecht.**

*Hypocotyl* erect, terete, glabrous, 8–10 mm. long, light green.

*Cotyledons* ovate-rotund, obtuse, entire, petiolate, glabrous, light green, without any apparent venation; petioles short, flat, shallowly furrowed on the upper side.

*Stem* erect, terete, herbaceous, ultimately woody; 1st internode 5–7 mm. long; 2nd and 3rd shorter.

*First leaves* simple, entire, cauline, alternate, broadly lanceolate, almost acuminate, acute, hairy when young, afterwards clothed with a very minute bloom, petiolate, exstipulate, green, pinnatinerved; petioles short, furrowed on the upper side.



**Schizanthus retusus**, *Hook.* (fig. 548).

*Primary root* long, tapering, stout, colourless, with a few lateral fibres, annual.

*Hypocotyl* mostly subterranean, glabrous, terete, colourless in the lower half, purple above, 1·5 cm. long.

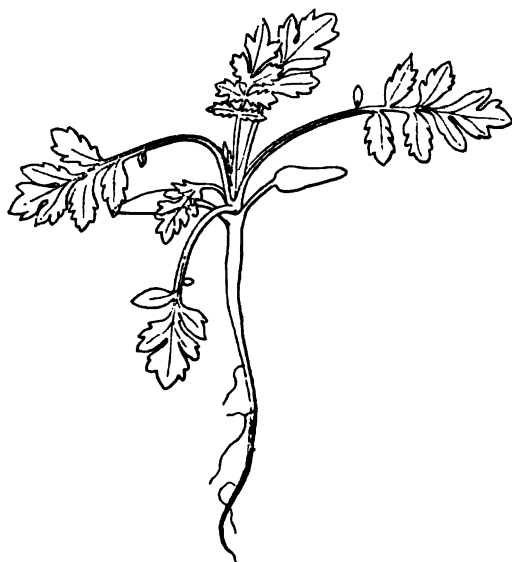


FIG. 548.—*Schizanthus retusus*. Nat. size.

*Cotyledons* foliaceous, bright green, glabrous, petiolate; lamina subulate-oblong, obtusely pointed, 1 cm. long, 8·5 mm. wide; petiole convex beneath, grooved above, 7 mm. long.

*Stem* annual and developed when about to flower.

*Leaves* pinnatisect, radical and cauline, opposite at least in seedling, exstipulate, petiolate, bright green, slightly pubescent when young, glabrescent; petioles channelled above, convex beneath, dilated at the base.

First pair slightly unequal, pinnatisect at the base, pinnatifid upwards, ovate in outline, obtuse; segments entire or slightly toothed.

Second pair ovate-oblong in outline, pinnatisect; lateral segments oblong, serrate; terminal lobe trifid with mostly entire segments.

Third pair similar but much more cut, with subpinnatifid segments.

*Browallia elata*, L. (fig. 549).

*Primary root* small, tapering downwards, with lateral fibres, annual.

*Hypocotyl* about 1 cm. long, .5 mm. thick, terete, slender, pubescent.

*Cotyledons* nearly equal, petiolate, 5 mm. long including the



FIG. 549.—*Browallia elata*. Nat. size.

petiole, 3.5 mm. wide, oblate, emarginate, obscurely nerved, slightly pubescent, pale green.

*Stem* very short, until it commences to grow for flowering.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, alternately incurvinerved and reticulate, hairy all over, membranous, deep green above, paler beneath.

Nos. 1 and 2. About 4 mm. long, 3 mm. wide at first, ovate, deeply serrate, rounded at the base and apex, hairy all over, distinctly incurvinerved and reticulate, bright green, thin.

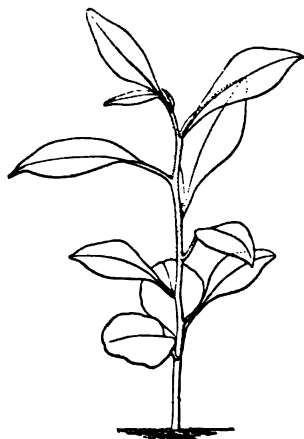


FIG. 550.—*Brunfelsia* sp.  
Half nat. size.

*Brunfelsia* sp. (fig. 550).

*Hypocotyl* woody, erect, terete, pubescent, soon becoming grey and throwing off the epidermis, about 1.8 cm. above the soil.

*Cotyledons* large, foliaceous, rotund-obovate, emarginate, coriaceous, petiolate, deep green above and thinly hairy, pubescent beneath, shining on both sides; laminæ variable in size from 1.5–1.9 cm. long, 1.5–1.8 cm. wide.

*Stem* woody, erect, terete, pubescent, pale green mottled with purple; 1st internode 8 mm. long; 2nd 6 mm.; 3rd 9 mm.; 4th 8 mm.; 5th 10 mm.; 6th 7 mm.

*Leaves* simple, entire, cauline, alternate, exstipulate, petiolate, thinly glandular-pubescent on both sides, coriaceous, shining, deep

or bright green above, paler beneath ; petioles short, channelled above, convex on the back, densely glandular-pubescent, brownish.

Nos. 1-3. Elliptic, obtuse, tapering most to the base.

Nos. 4-8. Lanceolate-elliptic, obtuse, tapering more or less to both ends.

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## SCROPHULARINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 913.

*Fruit and Seed.*—The ovary is superior and two-celled, sometimes imperfectly, with large placentas adnate to the septa, or stalked and peltate or bipartite. The ovules are usually very numerous in each cell, rarely reduced to two, and cover the placentas in many series. They are anatropous or amphitropous, both types sometimes occurring even in one genus. The fruit is capsular, rarely baccate. During dehiscence the placentas are left in the centre where they form a column, or they are liberated from the septa, or at other times remain adnate to valves carrying two half-septa each. The seeds are usually very numerous with a basal or ventral hilum and sessile, or they have a short and slender or sometimes a dilated funicle hidden by the incurved margin. The testa is membranous or crustaceous and reticulate, foveolate, strongly ribbed or pitted, rarely smooth ; in some cases it is hyaline and loose, while the endosperm is covered with a thin inner integument. Endosperm is generally copious and fleshy, rarely reduced to a thin layer or almost wanting. The embryo is comparatively large, and varies from half to nearly the whole length of the endosperm ; rarely minute ; it is generally straight but sometimes slightly curved, very rarely curved in the form of a ring. The cotyledons are shorter or longer, but not as a rule very much broader than the radicle which is superior or horizontal and directed towards the hilum.

Some cases occur in the Order—as in *Melampyrum*, *Tozzia*, *Leptorhabdos*, and a few species of *Veronica*—where the ovary has two ovules in each cell. The fruit is baccate

in *Teedia*, *Dermatocalyx*, *Halleria*, and *Leucocarpus*, and the one-seeded capsule of *Tozzia* dehisces rather tardily. Endosperm is very scanty in *Melosperma* and a few others ; and is altogether wanting in *Monttea* and *Wightia*.

The seeds are generally numerous and comparatively small ; but sometimes large and much modified in form. One of the simplest types is that occurring in *Scrophularia nodosa*. The seed is oblong or oval, undulated or rugose on the surface. The embryo is nearly as long as the endosperm with narrowly oblong cotyledons, shorter than the radicle. The seed of *Pedicularis gracilis* is obovoid and reticulate with the reticulations considerably elevated so as to form deep areolæ. The embryo is three-fourths the length of the seed, and the cotyledons are roundly oval, about equalling the radicle in length. The seeds of *Collinsia violacea* are broadly oval and flattened or slightly concave on the ventral face on which the hilum is situated.

The seeds of *Paulownia imperialis* are small, oblong, very numerous, and girt by a broad hyaline lacerated wing resembling a number of distinct appendages.

At least three very distinct types are met with in the genus *Linaria*. The seeds of *L. vulgaris* (fig. 552) are pendulous, anatropous, much flattened with the testa produced into a wing all round the margin except at the hilum where they are notched. The embryo is as long as the endosperm, and lies in the broader plane of the seed. The cotyledons are oval-oblong, shorter but much wider than the radicle, with their backs to the placental axis, but nearly always more or less oblique to it as if they had become twisted into this position owing to the flattening of the seed.

The ovules of *L. genistifolia* are horizontal and anatropous, while the mature seeds are oblong-obovoid and variously angled by being densely packed ; they are always broadest at the end abutting on the pericarp. The embryo is straight and nearly equals the endosperm in length, and the oval plano-convex cotyledons have their longitudinal axis at right angles to the placental axis. The latter character, however, varies somewhat according to the position of the seed on the placenta. In general characters, *L. Cymbalaria* (fig. 554)

agrees with *L. genistifolia*, but the seeds are globoso-ovoid, and the crustaceous testa is deeply ridged and furrowed longitudinally. The embryo is little more than half the length of the endosperm and has very short cotyledons. In *L. reticulata* the seed is slightly curved and transversely ridged. The embryo is also slightly curved in conformity with the seed.

A third type is represented by *L. purpurea* and *L. repens*. The seeds are peltate and transverse to the placenta, oval in outline, somewhat compressed dorsally, and variously angled by mutual pressure. The testa is thick, crustaceous, variously ridged, furrowed, and reticulate. The embryo is straight, nearly equalling the endosperm in length, while the oval cotyledons are much shorter than the terete radicle.

A somewhat similar variation of the seeds is met with in the genus *Veronica*. Four different types have come under my notice. The simplest is that met with in *V. serpyllifolia* (fig. 567). The seeds are anatropous, but the radicle may be superior, horizontal or inferior according to the position of the seed on the elevated cushion-like placenta. The seeds are also very minute and much flattened, but in transverse section oval or oblong according to their stage of maturity and other causes. The embryo varies from one-half to three-fourths the length of the endosperm, and the short cotyledons are scarcely wider than the radicle.

The ovules of *V. arvensis* are amphitropous and the seeds (fig. 562) peltate, dorsally flattened, variable in outline owing to mutual pressure and overlapping one another. The ventral face is somewhat concave with a central elevation on which the hilum is situated. The embryo is more than half the length of the endosperm, with ovate cotyledons much shorter than the radicle. *V. salicifolia* agrees pretty closely with *V. arvensis* notwithstanding the fact that the former is an erect shrub, while the latter is a procumbent annual herb. The seeds are however slightly less elevated on the ventral face, and the embryo is considerably shorter.

The ovules of *Veronica Buxbaumii* are pendulous, horizontal or ascending, and semianatropous, and the hilum varies accordingly. The seeds (fig. 563) vary from eight to twelve

in each cell, and are oblong, rounded at either end, deeply concave on one face and deeply ridged and furrowed on the dorsal or convex aspect. The short funicle is partly hidden at one end of the groove. The embryo is very similar to that of *V. salicifolia*, but relatively to the seed is very much shorter.

A fourth type occurs in *V. hederæfolia* (fig. 564) which bears only two ovules in each cavity of the ovary. The seed is large compared with any of the above, *V. Buxbaumii* excepted: it is deeply concave on the ventral face by the inrolling of the edges and the stout funicle arising from the centre of the cavity is almost or quite concealed. The seed both in longitudinal and transverse section greatly resembles that of a species of *Galium*. The embryo is much larger than that of *V. Buxbaumii*, situated at the upper end of the seed, and slightly curved in conformity with it.

In *Melampyrum* the seeds closely resemble, in form, size and colour, the pupæ of Ants; and I have observed that, whether by mistake or design, they are sometimes carried off by Ants into their nests. It is possible therefore that the similarity may be of use, as assisting in their dispersion.

*Seedlings*.—The cotyledons in this Order are generally moderate in size, and sometimes even small. The largest observed are some of the annual species of *Veronica*, the seeds of which are large and few in a capsule. They also become greatly elongated in many species of *Linaria* by intercalary growth after germination. They are always of simple types, and about half a dozen rather distinct kinds were observed.

The cotyledons of *Veronica salicifolia* are ovate or almost lanceolate and very small. The first two pairs of leaves are small, lanceolate and entire. Succeeding ones are more or less serrate and gradually increase in size, but retain the same shape. The ultimate ones are oblong-lanceolate, serrate and trinerved. The cotyledons of an unnamed species of *Scrophularia* are lanceolate and rather elongated. The first pair of leaves are broadly ovate and entire.

*Scrophularia chrysantha* may serve as a type with broadly ovate and entire cotyledons. The first pair of leaves are elliptic, and entire. The cotyledons of *Rhodochiton volubile*

(fig. 556) are very similar. The first two pairs of leaves are cordate and serrate, succeeded by three pairs which are larger, more acuminate, and very unequally serrate. An unnamed species of *Pedicularis* differs in having smaller and more obtuse cotyledons. The first pair of leaves are ovate-oblong, shallowly pinnatifid with rounded serrulate lobes.

The cotyledons of *Calceolaria chelidonioides* (fig. 551) are very small, suborbicular and entire. The first two pairs of leaves are broadly ovate and serrate; the third pair are triangular and pinnatifid. *Linaria Cymbalaria* (fig. 555) differs very much from all other species of the genus noticed. The cotyledons are small, rotund, entire, mucronate, and unequal in size. The hypocotyl remains very short and does not develop adventitious buds as in most other species. Branches are, however, given off from the axils of the cotyledons, and the stems are procumbent. The first pair of leaves are cordate-reniform and shallowly crenate; but the second pair are rather more acutely toothed.

A large proportion of seedlings have suborbicular and emarginate cotyledons. Those of *Collinsia bicolor* (fig. 559) are shallowly tridentate, and three- to five-nerved, but the venation is discernible only when the cotyledons begin to decay or dry up. The first three pairs of leaves are ovate, serrate, and subcordate at the base. *C. parviflora* and *C. multicolor* agree pretty closely with *C. bicolor*, except that the cotyledons are rather more decidedly emarginate. The first pair of leaves of *C. parviflora* are incipiently trifid; those of *C. multicolor* are crenate and emarginate. The cotyledons of *Paulownia imperialis* (fig. 558) conform to this type, but are very small. The first pair of leaves are roundly ovate and distantly dentate, succeeded by three pairs that are successively much larger, more decidedly cordate, and more deeply dentate. *Alonsoa incisæfolia* has the cotyledons and hypocotyl pilose, and the first pair of leaves are incise-serrate and relatively broader than in the adult. *Veronica Waldsteiniana* is notable for its dwarfed hypocotyl and the breadth of the first pair of leaves. An unnamed species of *Veronica* closely allied to *V. hederæfolia* is notable in the Order for the size of its cotyledons which are orbicular, trinerved throughout their length, with the lateral

nerves uniting with the midrib at its apex. They are also conspicuously emarginate with a tooth in the notch. The first pair of leaves are suborbicular and deeply incised with rounded teeth. *V. hederæfolia* (fig. 566) has also exceptionally large cotyledons, but they differ somewhat from any of the above in being oblong-oval and only slightly, if at all, emarginate. The large, concave seed and the mode of germination are shown in fig. 565. *Pentstemon Mackayanus* has entire or slightly emarginate cotyledons, and the first pair of leaves are broadly ovate and entire. Another slight departure from the type is met with in an unnamed species of *Calceolaria*, where the cotyledons are somewhat broader than long, and the two first leaves are broadly ovate and rather acutely serrate.

The seedling of *Scrophularia sambucifolia* (fig. 557) closely resembles that of some species of *Salvia*. The cotyledons are roundly triangular and obtuse. The two first pairs of leaves are cordate and crenate. The ultimate leaves are interruptedly pinnatisect and lyrate; the lower segments are small and roundly cordate and crenate, while the terminal one is very large and oblong-cordate; minute intermediate segments often occur between the larger ones. The cotyledons of *Torenia Fournieri* (fig. 561) are emarginate and slightly cordate at the base, but otherwise shaped like those of the last species. As they get very old they appear to lose the basal sinus and to become more reniform. The leaves are all ovate and serrate.

One of the most remarkable types is that in which the cotyledons greatly enlarge by intercalary growth, and alter their shape after germination, as happens in *Streptocarpus*, and in several genera belonging to the *Onagraceæ* already mentioned. I have noted it in *Mimulus luteus* (fig. 560) and in *Linaria*. The cotyledons of the former are triangular and incipiently trifid when full grown. The terminal tooth represents the original and true lamina of the cotyledons soon after germination. The seedling itself is dimorphic according to circumstances. If it has plenty of room to develop in the seed-bed the primary leaves are triangular, while the internodes of the stem are hardly developed; but if the seedlings are crowded, the primary internodes elongate considerably and the leaves become oval.



The cotyledons of *Linaria* become greatly elongated and are incipiently trifid. Those of *L. tristis* are cuneate-linear. The cotyledons of *L. genistifolia* are lanceolate or ovate-lanceolate and slightly constricted about the middle. The cotyledons of *L. striata* are elliptic and 3.5–4.25 mm. wide in the middle; and the primary leaves are in pairs. Those of *L. bipartita* (fig. 553) are linear and entire. The first five pairs of leaves are lanceolate and trinerved at the base.

A remarkable peculiarity of all the species of *Linaria* noticed except *L. Cymbalaria* is that the hypocotyl develops a group of adventitious buds from a point near the surface of the ground. The primary stem after producing a few pairs of leaves ceases to elongate. The adventitious buds or a number of them grow strongly and soon overtop the primary axis which they supersede, and constitute the flowering stems. Both annuals and perennials, with the exception above mentioned, behave in this way. The cotyledons often bear a close resemblance to the leaves of the primary axis. The tip above the constriction constitutes the original and true lamina of the cotyledon; all below it is developed as a result of intercalary growth subsequent to germination.

***Calceolaria chelidonioides*, H. B. K. (fig. 551).**

*Primary root* short, tapering, succulent and soft, with a few lateral fibres, annual.

*Hypocotyl* succulent, glandular-pubescent, merging into the root.

*Cotyledons* small, soon withering, pale green, petiolate; petiole 1.5 mm. long; lamina small, rotund, 2 mm. in diameter.

*Stem* erect, soft, succulent, green or purplish by exposure, sparsely glandular-pubescent; 1st internode 2 cm. long; 2nd 3 mm.; 3rd 5 mm.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, glandular-pubescent or hairy, deep green above, paler beneath; petioles convex, and glabrous on the under side, channelled above and glandular-hairy.

First pair very small, ovate, subacute, serrulate.

Second pair ovate, subacute, serrate, much larger than the first pair.



FIG. 551.  
*Calceolaria*  
*chelidonioides*.  
Nat. size.

Third pair triangular, subacute, pinnatifid at the base with the lobes oblong, obtuse, and like the upper part of the leaf simply or doubly serrate.

***Alonsoa incisaefolia*, Ruiz et Pav.**

*Hypocotyl* erect, terete, pubescent or hairy, 1.5–2.5 cm. long, light green or colourless.

*Cotyledons* membranous, ovate-rotund, obtuse, emarginate (though very young ones seem almost entire), petiolate, covered with rather long glandular hairs, light green, one-nerved.

*Stem* erect, terete, herbaceous; 1st internode 3–5 mm. long.

*First leaves* simple, deeply and obtusely serrate, cauline, opposite, acute, petiolate, exstipulate, covered with hairs, light green, pinnatinerved.

***Linaria purpurea*, Mill.**

*Ovary* two-celled, with about ten ovules in each cell; ovules peltate, amphitropous; micropyle at one end of the horizontal ovule.

*Capsule* obovoid, emarginate, postero-anteriorly furrowed at the junction of the carpels, two-celled, with six to eight seeds in each cell, dehiscing at the apex by two openings each with three teeth or valves, 8–8.5 mm. long, 3.5–4.25 mm. wide, 2.5–3 mm. thick.

*Seeds* peltate, or transverse to the receptacle, broader right and left of the attachment than above and below, somewhat compressed dorsally, variously angled by mutual pressure, reticulate and variously ridged and furrowed; testa thick, crustaceous, black when mature; hilum inconspicuous, ventral; micropyle transverse and either right or left of the axis.

*Seed* 1–1.25 mm. wide, .5–.6 mm. long and thick.

*Endosperm* copious, fleshy, white.

*Embryo* straight, colourless, nearly equal in length to the endosperm, transverse to the placenta; cotyledons oval, obtuse, entire, sessile, plano-convex, vertical to the axis with their backs to it; radicle terete, obtuse, horizontal, and pointing right or left of the placental axis.

***Linaria repens*, Steud.,** conforms to this type.

***Linaria vulgaris*, Mill. (fig. 552).**

*Ovary* two-celled, ovules many, seated all over a peltate enlarged placenta, pendulous, anatropous or semianatropous, radicle superior.

*Capsule* short, oblong, dehiscing at the apex by four to six valves, two-celled, many-seeded (seeds about one hundred and twelve). When fresh 8–10 mm. long and 5–7 mm. in diameter.

*Seed* orbicular, much imbricated, winged with a basal notch, sessile on a little projection of the placenta, flattened on the ventral aspect or slightly concave by the recurving of the marginal wing, convex and compressed laterally, with the central part containing the endosperm and embryo the thickest. Testa furnished with scattered minute raised points, finely and minutely reticulate especially towards the margin of the disc, the wing substrate, pale green when young, becoming white, ultimately black; hilum inconspicuous, superior and close to the micropyle, in or close to the basal notch of the wing of the seed, 1.75–2.25 mm. in diameter.

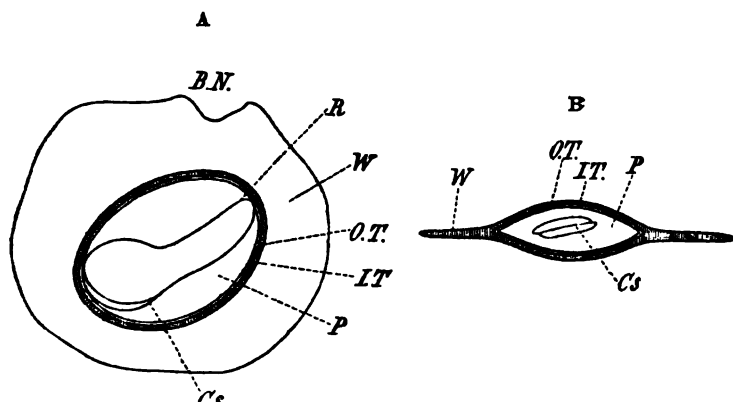


FIG. 552.—*Linaria vulgaris*,  $\times 20$ . A, longitudinal section of seed. B, transverse section of seed: BN, basal notch; W, wing; OT, testa; IT, tegmen; R, radicle; Cs, cotyledons; P, endosperm.

*Endosperm* copious, colourless, occupying the central disc of the seed, which is more or less oval, and lies obliquely to the hilum or basal notch.

*Embryo* curved, in most cases nearly equalling the diameter of the endosperm, colourless; cotyledons oval-oblong, obtuse, entire, plano-convex or nearly flat, closely adpressed face to face, and most often obliquely to one another, sessile, lying in the broader way of the seed with their backs to the axis; radicle terete, obtuse, superior, and close to the micropyle, much thinner than the width of the cotyledons and nearly twice as long.

*The two following Species agree with this Type.*

*L. saxatilis*, DC.

*Capsule* 3–4 mm. long, 3.4 mm. wide, and 2.75–3.25 mm. thick when fresh.

*Seeds* twenty to twenty-eight in a capsule about 1·5–1·75 mm. in diameter, much more decidedly echinulate all over the disc than those of *L. vulgaris*.

***L. alpina*, DC.**

*Capsule* opening by six valves, three- to six-seeded, twelve- to twenty-ovuled, 3·25–3·5 mm. long, 2·5–3 mm. wide, and 2–2·25 mm. thick.

*Seeds* orbicular, concave on the ventral aspect, 2–2·25 mm. in diameter.

***Linaria genistifolia*, Mill.**

*Ovary* two-celled, many-ovuled ; ovules horizontal, anatropous, seated on an elevated or enlarged placenta ; micropyle horizontal and abutting against the placental axis.

*Fruit* a capsule, broadly ovoid, obtuse, glabrous, subglaucous-green, two-celled, many-seeded, dehiscing at the apex by four valves.

*Capsule* 5·5–6 mm. long, 5–5·5 mm. wide, 4·5–5 mm. thick, containing one hundred and twenty to one hundred and thirty-six seeds.

*Seeds* oblong-obovoid, variously shaped and angled by mutual pressure, reticulate, densely packed horizontally all over the axis, broadest at the end abutting on the pericarp ; testa thick, crustaceous ; hilum basal, inconspicuous ; micropyle contiguous to the hilum.

*Seed* 1–1·25 mm. long, about ·75 mm. wide, and ·5 mm. thick.

*Endosperm* comparatively copious, but occupying only a small portion of the seed, fleshy, white.

*Embryo* straight, nearly equal in length to the endosperm, colourless, small ; cotyledons oval, obtuse, entire, sessile, plano-convex, with their long axis at right angles or perpendicular to the placental axis ; radicle terete, obtuse, considerably longer than the cotyledons, close to the hilum and pointing to the placenta.

**Seedling.**

*Primary root* tapering downwards, fibrous, perennial.

*Hypocotyl* terete, slender, glabrous, green or glaucous-green, 1–2 cm. or more above the soil, ultimately decumbent, sometimes proliferous immediately above the soil, and giving off one to six or more branches that soon become stronger and longer than the primary stem or plumule. This it is able to do even if the cotyledons and plumule should be broken off.

*Cotyledons* lanceolate or ovate-lanceolate, obtuse, narrowed into a short petiole, slightly constricted about the middle of the lamina,

glabrous, glaucous on both surfaces; lamina 4-6.75 mm. long, 2.25-4 mm. wide; petiole slightly channelled above, convex beneath, .5-1.75 mm. long.

*Stem* herbaceous, erect, terete, glabrous, glaucous-green; 1st internode 4-7.5 mm. long; 2nd shorter. First internode of branches from the hypocotyl 1-1.5 cm. long.

*Leaves* simple, entire, cauline, with the lower and primary ones opposite or in whorls of three to four, shortly petiolate, deeply glaucous on both surfaces, glabrous, trinerved at the base with a few alternate, ascending nerves upward, rather opaque, and best observed by transmitted light; petioles very short, tapering downwards, slightly channelled above, convex beneath.

First and second pairs lanceolate-elliptic, obtusely pointed.

First node on the branches bearing two, or on strong branches three elliptic or lanceolate-elliptic obtusely pointed leaves.

*Linaria reticulata*, Desf.

This species agrees with *L. genistifolia* in the horizontal anatropous ovules and seeds, but differs in the latter being slightly curved and transversely ribbed, not angled. The embryo is also similar, but slightly curved in conformity with the seed.

*Capsules* 3.5-4 mm. long, 3-3.25 mm. wide, 2.75-3.25 mm. thick, containing one hundred and thirty-three to one hundred and thirty-six seeds.

*Seeds* .75 mm. long, .25-.5 mm. wide, but variable and thickest at the end farther from the hilum.

*Linaria striata*, DC.

*Hypocotyl* as in *L. genistifolia*; 1.2-2.7 cm. above the soil, becoming early proliferous at the surface, and bearing three to five or more branches soon exceeding it in length and strength.

*Cotyledons* elliptic, obtuse, glabrous, glaucous-green and rather opaque above, paler beneath, with the midrib only discernible; lamina 7 mm. long, 3.5-4.25 mm. wide in the middle; petiole channelled above, convex beneath, glabrous, 1.5-3 mm. long.

*Stem*.—1st internode 1-1.3 cm. long; 2nd 1.65 cm.; 3rd 1-1.2 cm.

*Leaves* as in *L. genistifolia*.

First pair elliptic, obtuse.

Second pair narrower, lanceolate-elliptic or oblong-elliptic, obtuse.

First, second and third whorls on the branches similar to those on the primary stem, and wide or narrow according to the strength of the seedling.

*Linaria bipartita*, Willd. (fig. 558).

*Primary root* tapering downwards and giving off fibrous lateral rootlets.

*Hypocotyl* long, erect, slender, becoming thickened upwards, thinly glandular-pubescent, 2-8.5 cm. long, shining, green or more or less stained with red, proliferous at the surface of the soil, giving off buds that eventually grow stronger than the primary stem, and elongate from 2-6 cm. before producing any leaves, appearing thus as a continuation of the hypocotyl. If the upper part of the hypocotyl and cotyledons are removed after germination, the seedling has still power to grow and establish itself by means of this proliferation.

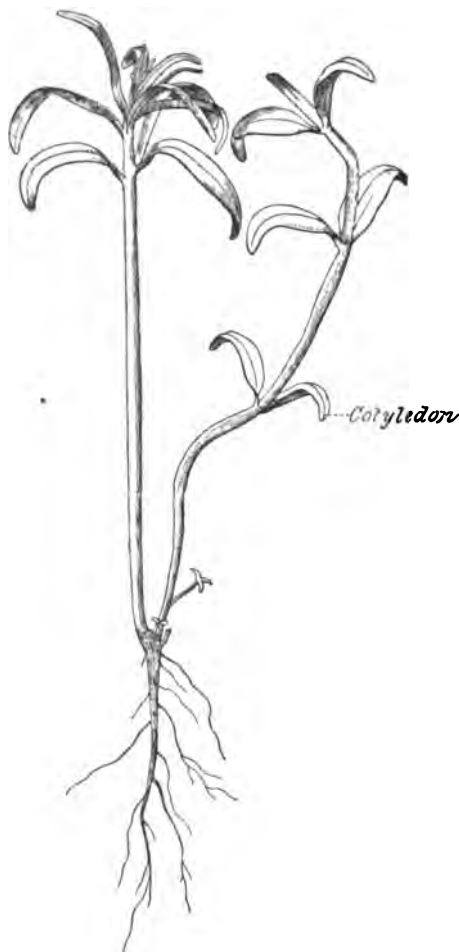


FIG. 558.—*Linaria bipartita*. Nat. size.

*Cotyledons* linear, obtuse, entire, tapered at the base to a short petiole, glabrous, bright green above, paler or subglaucous beneath, often recurved or more or less revolute at the tip, 1.1-1.3 cm. long including the very short petiole, 2.25-2.75 mm. wide, rather fleshy, distinctly one-nerved.

*Stem* herbaceous, erect, terete, thinly glandular-pubescent, green or more or less stained with red at the base; 1st internode 2-2.6 cm. long; 2nd about 1.6 cm.; 3rd shorter.

*Leaves* simple, entire, cauline, the lower opposite, or verticillate in whorls of three or more, the upper alternate, exstipulate, very shortly petiolate or sessile, glabrous, light or dark shining green above, subglaucous beneath, rather fleshy, trinerved at the base, with a few alternate ascending nerves upwards.

First to fifth pairs lanceolate, obtuse, trinerved at the base with a few indistinct alternate ascending nerves upwards, very shortly petiolate.

Leaves on the stems from the proliferous hypocotyl much narrower than those on the primary stem, linear and opposite, or in whorls of three, gradually tapered to the base.

*Linaria Cymbalaria*, Mill. (fig. 554).

*Capsule* 4·5–6 mm. long, 4–5·5 mm. wide, and 3–4·5 mm. thick, containing forty-two to eighty seeds.

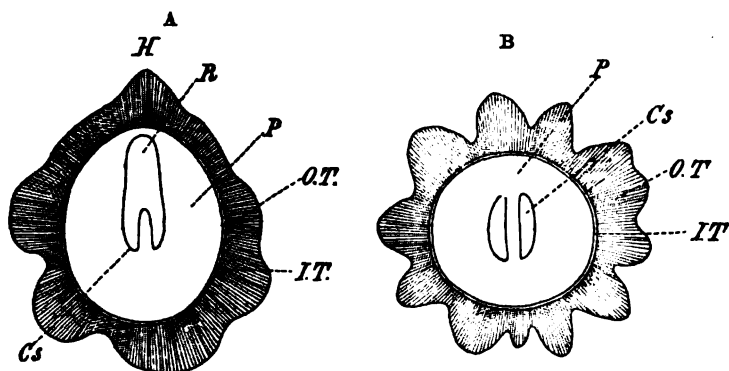


FIG. 554.—*Linaria Cymbalaria*,  $\times 40$ . A, longitudinal section of seed. B, transverse section of seed: R, radicle; P, endosperm; O.T, testa; I.T, tegmen; Cs, cotyledons; H, hilum.

*Seeds* oval or globose-oval, deeply ridged and furrowed longitudinally with a very thick testa, 1 mm. long, .75 mm. in diameter.

*Embryo*.—The cotyledons with their edges vertical to the axis, but varying apparently according to the position of the seed in the capsule.

*Seedling* (fig. 555).

*Primary root* slender, flexuose, with very fine lateral rootlets.

*Hypocotyl* decumbent, subflexuose, thinly pubescent, tapering indistinguishably into the root, not giving rise to adventitious buds.

*Cotyledons* rather unequal, thinly pubescent, pale green, rotund or subreniform, mucronate, entire, 4·5 mm. long, 5 mm. wide; petiole thinly pubescent, channelled above, about 7–9 mm. long.

*Stem* herbaceous, trailing, terete, thinly pubescent, green or purplish, brittle, succulent; 1st internode 6 mm. long.

*Leaves* alternate (first four to six in opposite pairs, but developing unequally from the bud), thinly pubescent in seedling stage but glabrous or almost so in the adult plant, green or stained with purple on the under side, and especially the petioles; petioles slightly channelled on the upper side, subterete, thinly pubescent in the seedling stage, glabrous or almost so in the adult stage, green or purplish.

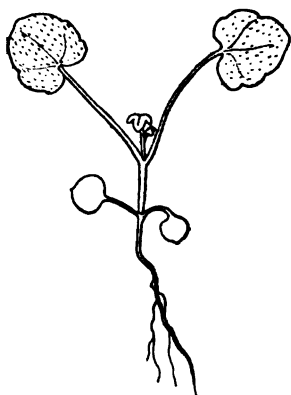


FIG. 555.—*Linaria cymbalaria*.  
Nat. size.

First pair cordate-reniform, mucronate, shallowly three- to five-crenate, obscurely trinerved.

Second pair cordate, rather acutely five- to seven-toothed, obscurely five-nerved.

Ultimate leaves alternate on the trailing stems and branches, reniform, five- to seven-nerved, with five to seven large, rounded, mucronate crenatures on the lower and larger leaves, and five to seven triangular or ovate, deep, acute teeth on the smaller and upper leaves.

### *Linaria tristis*, Mill.

*Hypocotyl* colourless, becoming proliferous at the surface of the ground, and throwing out from one to many buds which develop into branches with verticillate leaves, three to four in the first whorl, 1.5–2 cm. long.

*Cotyledons* cuneate-linear, narrowed gradually to the base, constricted above the middle or towards the apex, and appearing tridentate there with the lateral teeth rudimentary and the terminal subulate, obtuse or subacute, opaque, deep subglaucous-green and convex above, paler beneath and concave, 9–12 mm. long, 2.5–3 mm. wide immediately beneath the constriction where they are widest.

*Stem* herbaceous, erect, terete, glabrous, pale green; 1st internode 8–9 mm. long; 2nd shorter.

*Leaves* verticillate, narrowed to the base but scarcely petiolate, glabrous, deep opaque green or glaucous above, paler beneath.

First whorl of four leaves linear, obtuse, flat or subrevolute at the margins, glaucous in the seedling.

Second whorl very frequently consisting of five leaves similar to the first. The whorl sometimes consists of four leaves. Occasionally



a leaf of the first whorl is carried up on the internode above it, and occasionally a leaf of the second whorl may be below the level of the others.

Above this the most frequent number of leaves in a whorl seems to be four; but it varies from three to five, and occasionally the whorls are broken or interrupted.

Ultimate leaves four to five in a whorl, lanceolate-linear, sub-acute, deep opaque or glaucous-green, with a shallow channel above, paler beneath with a prominent midrib and two faint lateral nerves near to and parallel with the margin, and indistinct, alternate, ascending nerves passing from the midrib to the submarginal nerves.

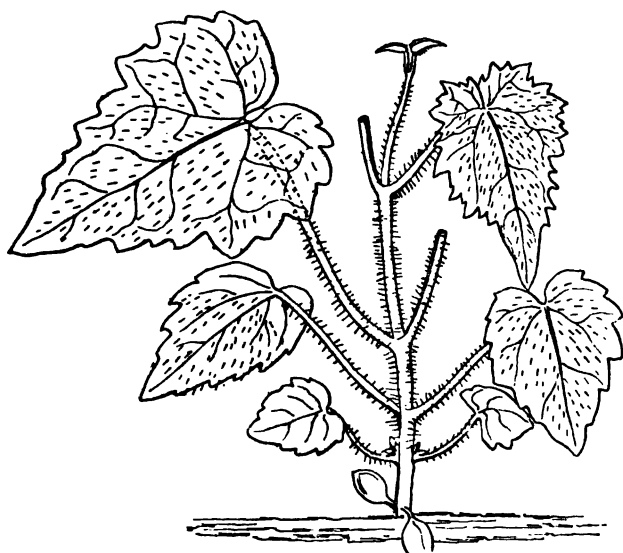


FIG. 556.—*Rhodochiton volubile*. Nat. size.

***Rhodochiton volubile*, Zucc. (fig. 556).**

*Hypocotyl* subterranean or short.

*Cotyledons* petiolate, coarsely and thinly hairy; lamina rotund-ovate, apiculate, 6 mm. long, 5 mm. wide; petiole channelled above, tapering downwards, 3 mm. long.

*Stem* erect, terete, thick and succulent at the base, and becoming much more slender upwards as it commences to twine, villous, purplish; 1st internode 7 mm. long; 2nd 5.5 mm.; 3rd 9.5 mm.; 4th 9.5–10 mm.; 5th 1.6 cm.

*Leaves* simple, cauline, opposite, decussate, exstipulate, petiolate,

coarsely hairy on both sides with stiff hyaline hairs; petioles channelled above, and hairy like the leaves and stem, purplish.

First pair small, cordate, acute, crenate-dentate with mucronate teeth; lamina 1·8 cm. long, 1·1 cm. wide.

Second pair cordate, acute, serrate-dentate with mucronate teeth, faintly five-nerved.

Third pair cordate, acuminate, serrate-dentate, acute or sublobulate below the middle, strongly nerved with five ascending and incurved nerves, and subreticulate.

Fourth pair cordate, acuminate, acute, acutely dentate-serrate, sublobulate on the lower half, nerved like the third pair.

**Scrophularia sambucifolia, L. (fig. 557).**

*Primary root* soon ceasing to elongate, and giving off almost horizontal secondary ones near its base.

*Hypocotyl* erect, terete, slender, pubescent, pale purplish, 1–1·8 cm. long, .75 mm. thick.

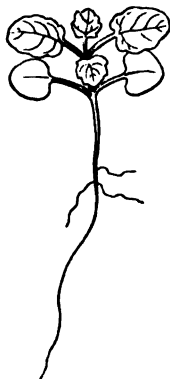


FIG. 557.  
*Scrophularia*  
*sambucifolia.*  
Nat. size.

*Cotyledons* roundish-triangular, obtuse, glabrous, convex above; lamina 5·5 mm. long, 6 mm. wide; petiole channelled above, convex below, pubescent, 6 mm. long.

*Stem* slender, erect, terete, hairy, pubescent, herbaceous; 1st internode 2·5 mm. long; 2nd 1 mm.

*Leaves* cauline, simple, opposite, decussate, exstipulate, petiolate, glandular-pubescent or hairy on both surfaces as well as on the petioles.

First pair rotund-cordate, obtuse, shallowly crenate.

Second pair rotund-cordate, more deeply crenate than the first pair.

Ultimate leaves lyrate, interruptedly pinatisect, crenate with mucronate serratures, glandular-pubescent above and on the nerves beneath, and dotted with sessile glands, alternately penninerved, reticulate, rugose; terminal segment cordate-oblong, obtuse; lateral segments alternate, more or less imbricate, rotund-cordate, obtuse, unequal at the base, more or less cut away on the anterior basal side, decurrent on the petiole with a narrow wing, and irregularly interspersed with minute segments; larger segments three to five.

**Scrophularia chrysantha, Jaub. et Sp.**

*Hypocotyl* covered with numerous glandular hairs, light green or almost colourless, 5–8 mm. long.

*Cotyledons* rotund-ovate, about 5 mm. long including the petiole.

*Stem* with primary internodes but slightly developed.

*First leaves* elliptic, subacute, entire, shortly petiolate, covered with glandular hairs and ciliated.

*Paulownia imperialis*,<sup>1</sup> Sieb. et Zucc. (fig. 558).

*Hypocotyl* erect, terete, very short, glandular-pubescent, about 5 mm. long.

*Cotyledons* transversely oval or rotund, petiolate, shallowly emarginate, showing a midrib only, thinly glandular-pubescent or glabrous, light green above, paler beneath; lamina about 4.5 mm. long, 5.5 mm. wide; petiole flattened above or slightly grooved, 3-4 mm. long.

*Stem* erect, terete, densely glandular-pubescent or shaggy, and almost villous in a young state, ultimately woody, forming a tree; 1st internode 5.5 mm. long; 2nd 1.15 cm.; 3rd 1 cm.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, alternately ascendingly incurvinerved, with the nerves uniting at their upper end and giving off branches into the marginal teeth, reticulate, softly and densely glandular-hairy on both surfaces, deep green above, paler beneath; petioles subterete, narrowly channelled above, densely glandular-hairy and shaggy, tapering upwards from a stout base.

First pair small, broadly ovate or rotund-ovate, obtuse, distantly glandular-dentate.

Second pair cordate, obtuse, irregularly glandular-dentate.

Third pair much larger, cordate, subacute, dentate, with unequal-sized teeth generally largest about the middle of the leaf, and tipped with a glandular mucro.

Leaves on vigorous young trees attain a length of twelve to twenty-four inches exclusive of the petiole.

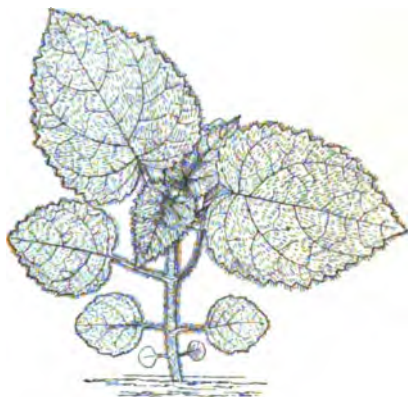


FIG. 558.—*Paulownia imperialis*.  
Half nat. size.

<sup>1</sup> The seed is figured by Tubeuf, *Samen, Früchte und Keimlinge*, p. 74.

***Pentstemon Mackayanus*, Knowl. et Westc.**

*Hypocotyl* erect, terete, minutely pubescent, 4–6 mm. long, light green or colourless.

*Cotyledons* ovate-rotund, obtuse, entire or sometimes minutely emarginate, petiolate, glabrous, dark green, with no apparent venation.

*Stem* erect, terete, herbaceous, finely pubescent, light green; 1st internode 3–5 mm. long; 2nd much shorter.

*First leaves* simple, cauline, opposite, decussate, ovate, obtuse, petiolate, exstipulate, with a few scattered hairs, trinerved with indistinct upper lateral veinlets; the first pair are entire; the second crenate.

***Collinsia bicolor*, Benth. (fig. 559).**

*Primary root* long, tapering, with fibrous lateral rootlets, annual.

*Hypocotyl* erect, terete, minutely pubescent, green or reddish-purple, 1.3–1.5 cm. long.

*Cotyledons* rotund, or rotund-ovate, rounded at the base, minutely emarginate at the apex, fleshy, glabrous except the petioles, dull light green or stained with red and dotted with white; lamina 5–10 mm. long, and as wide, or slightly longer than wide; petioles semiterete, channelled above, minutely pubescent, dilated towards the base and connate, 6.5–9.5 mm. long. Lamina obscurely and alternately incurvinerved, and reticulate, venation seen only when the cotyledon is decaying.

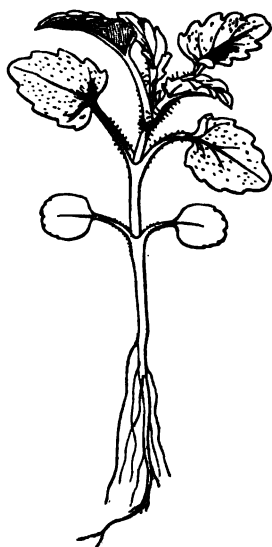


FIG. 559.—*Collinsia bicolor*.  
Nat. size.

*Stem* herbaceous, annual, erect, terete, minutely pubescent with deflexed hairs, or subglabrous, pale green or stained red; 1st internode 7–13 mm. long; 2nd 4–13 mm. according to strength of plant.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, thinly hairy above, subglabrous beneath, alternately and ascendingly penninerved, deep opaque green above and dotted with white, much paler, almost glaucous beneath and shining; petioles semiterete, channelled above, hairy, dilated towards the base and subconnate.

First pair ovate, obtuse, subcordate at the base, crenate-serrate. This is the most common type, but seedlings occur frequently with the first pair of leaves deeply trilobed; lateral lobes unequally oblong or unequally obovate with a few teeth on the posterior side; terminal lobe oblong-cuneate or rhomboid-cuneate, crenate or obtusely dentate.

Second pair ovate, obtuse, shallowly cordate at the base, obtusely serrate. This is the usual type, but more rarely the second pair become lobed like the first.

Third and fourth pairs oblong-ovate, obtuse, rounded or sub-cuneate at the base, coarsely, obtusely, and irregularly serrate. Rarely the third pair are lobed and a detached portion may sometimes be seen on the petiole.

***Collinsia parviflora*, Dougl.**

*Hypocotyl* very similar to last species.

*Cotyledons* very similar to those of *C. bicolor*, almost orbicular, emarginate, obtuse, dark green, reddish below, very indistinctly one-nerved.

*Stem* with primary internodes very slightly developed.

*First leaves* showing a tendency to become trilobed, slightly emarginate, ovate, obtuse, petiolate, minutely pubescent, dark green stained with purple beneath, indistinctly pinnatinerved.

***Collinsia multicolor*, Paxt.**

*Hypocotyl* as in *C. bicolor*, but 3-5 cm. long, and light green or colourless.

*Cotyledons* fleshy, ovate or almost round, emarginate, sometimes almost cordate at the base, glabrous except on the petioles, dark green, pinnatinerved like the leaves, with prominent venation.

*Stem*.—1st internode 4-5 mm. long.

*First leaves* ovate-oblong, emarginate, crenate, petiolate, pubescent, light green, pinnatinerved.

***Mimulus luteus*, L. (fig. 560).**

*Primary root* normal.

*Hypocotyl* short, tapering insensibly into the root, glabrous.

*Cotyledons* triangular, obtuse, incipiently tridentate near the apex with the middle tooth much the largest and longest, traversed

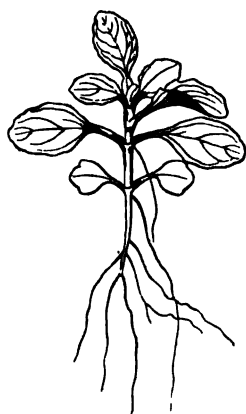


FIG. 560.—*Mimulus luteus*.  
Nat. size.

longitudinally with an indistinct midrib (no other nerves discernible when fresh), glabrous, light green; lamina 4-5 mm. long, 3.5-4.5 mm. wide; petiole channelled above, slender, 2.5-4 mm. long.

*Stem* herbaceous, erect, terete, pale green, glabrous; primary internodes undeveloped unless the seedlings are crowded when more or less elongation takes place. Adventitious roots are frequently emitted from the stem where in contact with the soil.

*Leaves* simple, radical and cauline, opposite, exstipulate, petiolate, alternately penninerved, with the nerves incurved and uniting with those above them, light green and punctate on the upper surface, paler beneath, glabrous or thinly hairy on the same plant; petioles glabrous, channelled above, dilated at the base and connate.

First and second pairs variable; in seedlings with sufficient room to develop they are deltoid, obtuse, obscurely or obsoletely dentate, with a prominent midrib and a few alternate incurved lateral nerves; in crowded seedlings they are oval.

***Torenia Fournieri*, Lind. (fig. 561).**

*Primary root* normal, short, tapering, giving off short lateral rootlets, annual.

*Hypocotyl* soft, herbaceous, erect, terete, 1.5 cm. long.

*Cotyledons* petiolate, persistent; limb triangular-emarginate, subtruncate at the base, 4 mm. long, 6 mm. wide; petiole 2 mm. long.

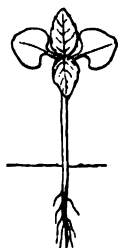


FIG. 561.  
*Torenia*  
*Fournieri*.  
Nat. size.

*Stem* erect, square with acute angles, thickened at the nodes and ciliate at the angles, succulent, pale green; 1st internode 6 mm. long; 2nd 1.2 cm.; 3rd 2.6 cm.; 4th 8 mm.

*Leaves* simple, cauline, opposite, decussate, exstipulate, petiolate, triangular, or triangular-ovate, acute, acutely penninerved, with the nerves sunk on the upper side, and prominent beneath, pubescent on both surfaces, gradually increasing in size from the seedling stage of the plant to the adult; average size of leaf 2.2 cm. long, 8-10 mm. wide; petioles channelled above, convex beneath, pubescent, increasing in length from seedling to middle of stem in the adult plant, then again becoming shorter; average length about 1.5 cm.

***Veronica arvensis*, L. (fig. 562).**

*Ovary* two-celled, many-ovuled; ovules amphitropous on axile placentas; micropyle superior.

*Fruit* a capsule, obcordate, much compressed laterally, keeled,

glabrous except on the keel which is coarsely hairy, two-celled, many-seeded, dehiscing at the apex with four valves.

*Seed* peltate, broadly oblong, or of various outlines, convex dorsally, flattened ventrally with an oblong or obovate, elevated hilum, imbricating and lying obliquely to the flattened sides of the ovary, pale straw- or almost amber-coloured; micropyle at the upper end.

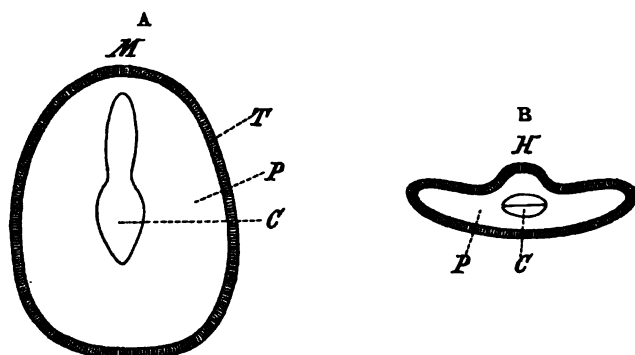


FIG. 562.—*Veronica arvensis*,  $\times 80$ . A, longitudinal section of seed: M, micropyle; T, testa; P, endosperm; C, cotyledon. B, transverse section of seed: P, endosperm; C, cotyledon; H, hilum.

*Endosperm* in the mature seed copious, fleshy, white, embedding and surrounding the embryo.

*Embryo* rather small, considerably shorter than the endosperm, colourless; cotyledons ovate, obtuse, plano-convex, lying in the broad plane of the seed, with their backs to the placenta; radicle terete, obtuse, pointing to the micropyle at the upper end of the seed, somewhat longer than the cotyledons, and narrower or thinner.

### *Veronica Buxbaumii*, Ten. (fig. 563).

*Ovules* pendulous, horizontal or ascending, anatropous or nearly so, with the micropyle close to the hilum, and consequently superior, horizontal or inferior.

*Capsule* much compressed laterally, bifid, with widely diverging, obtuse, keeled lobes, glandular-hairy all over, dehiscing when mature by four apical valves, with about eight to twelve seeds in each of the two cells, attached by a very short pale or colourless funicle to papillose projecting processes of the placentas which are deep green before the capsule dries up.

*Seed* oblong, rounded at both ends, or somewhat narrowed to the basal and attached end, transversely ridged and grooved on the dorsal and convex aspect, concave on the sides facing one another,

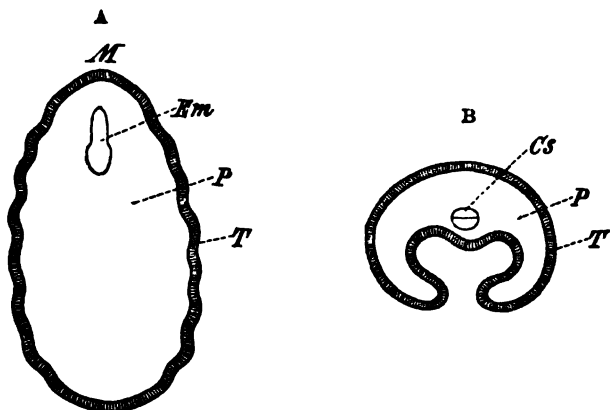


FIG. 563.—*Veronica Buxbaumii*,  $\times 90$ . A, longitudinal section of seed. B, transverse section of seed: *M*, micropyle; *Em*, embryo; *P*, endosperm; *Cs*, cotyledons; *T*, testa.

and containing or surrounding the raphe and funicle in this groove, glabrous, white before maturity; raphe lying along the

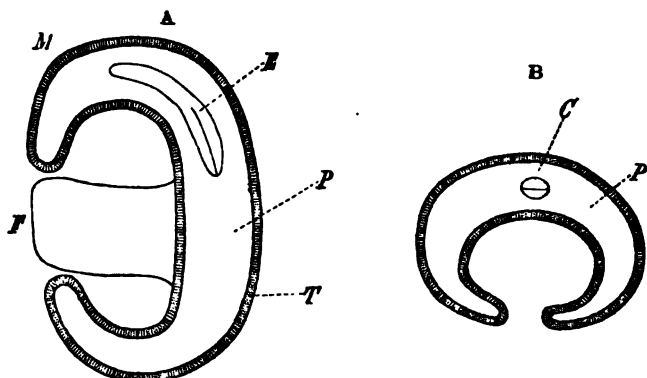


FIG. 564.—*Veronica hederifolia*,  $\times 15$ . A, longitudinal section of seed. B, transverse section of seed: *F*, funicle; *E*, embryo; *P*, endosperm; *T*, testa; *M*, position of micropyle; *C*, cotyledons.

median line in the groove; funicle very short; micropyle contiguous to, but a little higher up than the hilum, on, or towards the external aspect.



*Endosperm* in the mature seed copious, fleshy, white, occupying nearly the whole seed.

*Embryo* small, straight, colourless, at right angles to the placenta; cotyledons broadly ovate, obtuse, entire, plano-convex, lying in the broader way of the seed with their backs to the raphe on one side and to the dorsal aspect on the other; radicle oblong, obtuse, pointing to the micropyle, but some little distance from the extreme apex of the seed, slightly longer than the cotyledons.

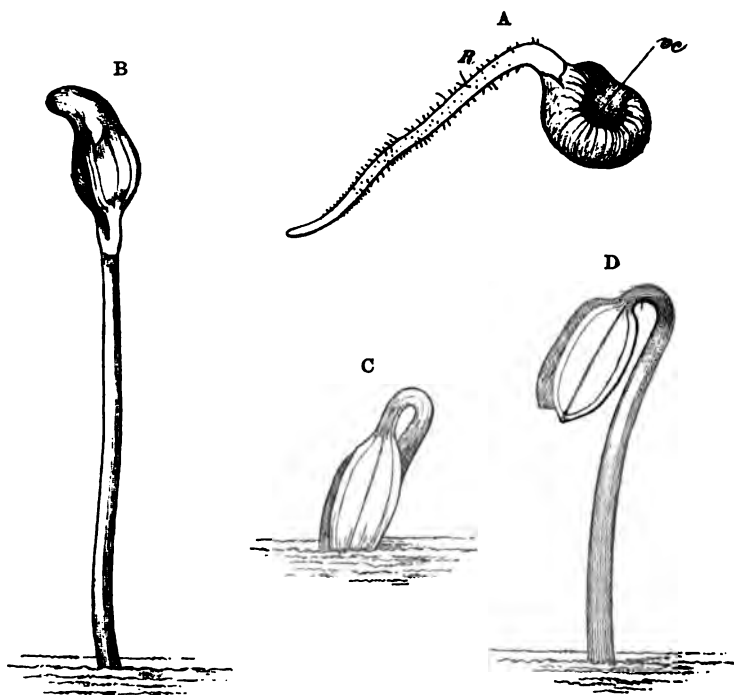


FIG. 565.—*Veronica hederæfolia*. A, seed germinating: *R*, radicle; *ec*, ventral cavity of seed,  $\times 4$ . B, another seedling,  $\times 4$ . C, seedling,  $\times 4$ , showing mode of germination when the seed is well buried. D, another stage of C,  $\times 4$ .

*Veronica hederæfolia*, *L.* (figs. 564–66).

*Ovary* with each of the two cells two-ovuled; ovules peltate, amphitropous; micropyle superior.

*Capsule* broadly obovoid or subglobose, turgid and slightly emarginate, shallowly grooved along the side where the union of the carpels forms a double partition, with a slender filiform ridge along

the dorsal suture, and shallowly grooved or not in that part, glabrous, each cell one- or two- (generally two-) seeded, dehiscing at the dorsal suture and separating or breaking away from the placental column.

*Seed* in the early stage forming a little curved or reniform papilla suspended by a colourless hilum, increasing greatly in length and breadth but not thickness, till it becomes an oblong, flattened body. Growth continues in the middle and dorsal region, but not at the edges, until the seed assumes an oblong-sphaeroid form, peltate on the funicle and concave on the ventral aspect, completely enclosing and hiding the colourless funicle, transversely and shallowly grooved towards the margin, pale amber-coloured or nearly white, glabrous; micropyle at the upper end of the seed and external to the ventral cavity; funicle stout, colourless, obliquely ascending, enclosed by the involute edges of the seed; hilum ventral in the cavity.

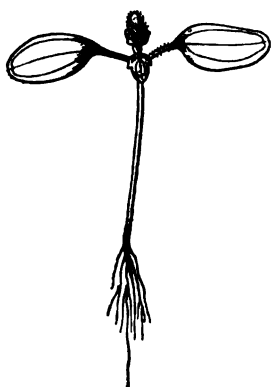


FIG. 566.  
*Veronica hederifolia*.  
Seedling, nat. size.

*Endosperm* in the mature seed copious, fleshy, firm, white.

*Embryo* small, slightly curved in conformity with the curvature of the seed, embedded in the centre of the endosperm at the upper end of the seed, colourless; cotyledons oblong, obtuse, entire, trinerved, plano-convex; radicle terete, obtuse, a little longer than the cotyledons, close to the micropyle at the upper end of the seed but completely surrounded by the endosperm.

*Germination*.—Seeds sown on the 29th of June commenced to germinate on the 7th of December.

An early stage (fig. 565, A) shows the radicle pushed out from the seed and furnished with root-hairs; the ventral cavity of the seed is very conspicuous.

Three days later (fig. 565, B) the hypocotyl is straight, thinly hairy at the very top and on the petioles of the cotyledons. The latter are trinerved, glabrous except the petioles, and have nearly got out of the membranous, now empty testa.

When the seed is moderately well buried in the soil, the radicle pushes out first and fixes the plant in the soil, then the hypocotyl arches and in straightening pulls the cotyledons out of the seed (fig. 565, C).

Two days later (fig. 565, D) the cotyledons get clear out of the

seed, an easy process when the seed is properly covered with soil. The hypocotyl elongates greatly meanwhile.

***Veronica serpyllifolia*, L. (fig. 567).**

*Ovules* numerous, pendulous, horizontal, ascending and erect from an elevated, knob-like axile placenta, anatropous; micropyle superior, horizontal or inferior, and next to the hilum.

*Capsule* broadly obcordate, much compressed laterally and keeled, glandular-pubescent on the keel, otherwise glabrous, two-celled, with the septum in the narrow way of the fruit, many-seeded, dehiscent by four valves when mature, tipped with the slender persistent style which is much longer than the apical notch.

*Seeds* broadly oval-oblong or obovate-oblong, much compressed laterally, obtuse-edged, very small and numerous, pale-coloured, yellowish-white just before maturity; testa thin; raphe and chalaza on one of the flattened faces; funicle very short; hilum and micropyle basal.

*Endosperm* in the mature seed copious, fleshy, whitish.

*Embryo* small, straight, colourless, about three-fourths the length of the endosperm; cotyledons ovate, obtuse, entire, plano-convex, lying in the broad way of the seed with their edges to the axis or placenta; radicle terete, obtuse, slightly longer than the cotyledons, embedded in the endosperm near the hilum.

***Veronica salicifolia*, Forst.**

*Ovary* as in *V. arvensis*.

*Capsule* ovate or ovoid, laterally compressed, pubescent especially towards the edges, two-celled, many-seeded, dehiscent for more than half its length into four valves, each of which is acute or subacuminate and more or less conspicuously trinerved.

*Seed* peltate, closely resembling that of *V. arvensis*.

*Endosperm* copious, occupying almost the whole interior of the seed, whitish.

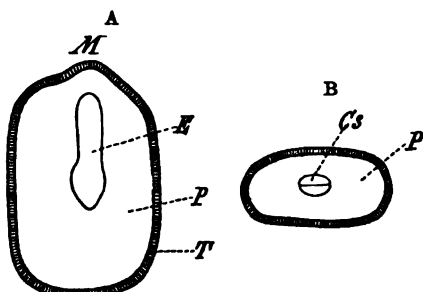


FIG. 567.—*Veronica serpyllifolia*,  $\times 40$ .  
A, longitudinal section of seed. B, transverse section of seed: M, micropyle; E, embryo; P, endosperm; T, testa; Cs, cotyledons.

*Embryo* small, less than half the length of the endosperm, straight, otherwise as in *V. arvensis*.

### Seedling.

*Primary root* slender, flexuose, soon exceeded in length by the lateral rootlets.

*Hypocotyl* short or indistinguishable from the root.

*Cotyledons* small, ovate, obtuse or subacute, petiolate, glabrous; lamina 2.5 mm. long, 2 mm. wide; petiole grooved above, .5 mm. long.

*Stem* shrubby, erect, terete, pubescent in the seedling, glabrous in the adult plant, pale green, shining; 1st and 2nd internodes 2.5-4 mm. long; 3rd 2.5 mm.

*Leaves* simple, cauline, opposite, decussate, exstipulate, petiolate, glabrous and shining on both surfaces, coriaceous, evergreen, deep green above, pale beneath, obscurely alternately penninerved and reticulate; petioles short, grooved on the upper side, semiamplexicaul, glabrous.

First pair lanceolate-elliptic, obtuse, entire.

Second pair lanceolate-elliptic, entire, subacute.

Third pair lanceolate-elliptic, acute, with one or two serratures on each side.

Intermediate forms are lanceolate, acute, serrate.

Ultimate leaves oblong-lanceolate, acuminate, acute or tipped with a mucro, serrulate, minutely pubescent or scaberulous at the margin, as are the intermediate forms, but not those in the younger seedling stage, three- or faintly five-nerved in the lower half.

### *Veronica Waldsteiniana*, ? *Hort.*

*Hypocotyl* short, erect, terete, glabrous, 1-1.5 mm. long, light green or colourless.

*Cotyledons* ovate, obtuse, emarginate, membranous, petiolate, glabrous, green, indistinctly one-nerved.

*Stem* erect, terete, herbaceous, hairy; 1st internode .75-1 mm. long; 2nd shorter.

*First leaves* simple, cauline, opposite, decussate, broadly ovate, obtuse or subacute, serrate, hairy, petiolate, exstipulate, light green, distinctly and alternately pinnatinerved.

### *Veronica* sp. (*V. hederæfoliæ* aff.).

*Primary root* tapering downwards, fibrous, annual.

*Hypocotyl* erect, terete, pale green or colourless, glabrous at the base and hairy upwards, elongating in heat to 6 or 7 cm.

*Cotyledons* orbicular, foliaceous, emarginate, with a glandular mucro in the sinus, trinerved from the petiole to the apex where the lateral nerves unite with the midrib immediately below the mucro, with a few indistinct reticulations outside and inside of the strong laterals, glabrous, dark green above, paler beneath; lamina 1.2 mm. long, and as wide; petiole slender, semiterete, channelled above, subperfoliate, hairy, pale green, about 1.7 cm. long.

*Stem* erect, more or less quadrangular, with obtuse angles, pale green, densely hairy or subvillous; 1st internode 1.5 cm. long.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, densely hairy on both surfaces, trinerved from the base in the seedling, light green; petiole short, channelled above, densely hairy.

First pair rotund, obtuse, cordate at the base, crenate-dentate with obtuse teeth tipped with a glandular mucro, trinerved from the petiole to the apex, with the primary lateral nerves running into a tooth on each side of the apical one, and short lateral branches running into the other teeth from the primary lateral nerves.

Ultimate leaves rotund-reniform or reniform, five- to seven-nerved, obtusely five- to seven-toothed, rarely nine-toothed, coarsely hairy on both surfaces but not glandular; teeth tipped with a glandular mucro. Bracts similar to the leaves and not much smaller, falling short of the peduncles.

*Fruit* didymous, turgid and furrowed along the midrib of the carpels, not carinate, densely hairy but not glandular, with a sunk cavity at the apex in which the persistent style is situated, two-celled, each cell two-seeded.

### ***Pedicularis* sp.**

*Root* small, yellowish, with a few rootlets and root-hairs.

*Hypocotyl* 5 mm. long, .5 mm. thick, terete; hairs purplish-red.

*Cotyledons* equal, 4 mm. long including the glandular-ciliate, purplish petiole, 2 mm. wide, ovate, rounded at the base, obtuse at the apex, entire, obscurely nerved, glandular-ciliate, thin, purplish.

*Stem* with the primary internodes undeveloped.

*Leaves* simple, once, twice, or still further pinnately cut, radical and cauline, apparently opposite in the seedling, exstipulate, petiolate, with venation conforming to the divisions, hairy.

First pair oblong-ovate, shallowly pinnatifid with rounded serrulate lobes, 1 cm. long including the petiole, and 4 mm. wide.

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## GESNERACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 990.

*Fruit and Seed.*—The ovary is inferior, half or wholly superior and one-celled with two parietal placentas which are bifid and slender or strong, and consist each of two broad revolute plates approaching one another in the centre of the cell, imperfectly dividing it into two or four locelli; rarely do they cohere at the base or beyond the middle of the cell as in *Monophyllæa* and *Loxophyllum*. The ovules are generally very numerous, and densely cover the placentas on all sides or at their margins only; they are also minute and anatropous. The fruit is capsular, rarely fleshy, and in the *Gesneresæ* dehisces by two valves between the persistent calyx-lobes, or rarely at a dorsal slit at the base as in the genus *Monopyle*. In the tribe *Cyrtandree* it is indehiscent, or bursts transversely, sometimes by two valves along the middle of the carpels, or at the placentas. In other cases it is four-valved with the valves bearing both divisions of the placentas on their middle or a half of the placentas on their margins; the valves rarely become entirely separated from the placentas. The seeds are very numerous and minute, pendulous or horizontal and ovoid, oblong, fusiform or linear with a striated or reticulate testa drawn out into a short point or a long thread-like process at either end. Endosperm is more rarely scanty and fleshy, copious or absent. The embryo is straight and nearly as long as the endosperm when that is present, with short cotyledons and a radicle pointing to the hilum.

*Seedlings.*—The cotyledons of seedlings in this Order are always very small unless one or both become foliaceous by intercalary growth. Those of *Sinningia speciosa* are small, rotund and never attain any great size. *Gesnera macrantha* has broadly ovate or triangular cotyledons, glandular on both surfaces and showing a midrib only. The hypocotyl commences to thicken soon after germination and forms a fleshy, globular and persistent rootstock, as does also *Sinningia speciosa*. The first pair of leaves in *Gesnera macrantha* are

roundly ovate and entire; the second pair are roundly oval with a few crenatures; and the third pair are cordate-ovate and crenate. All the three pairs are developed close to the ground.

A very curious case presents itself in the different species of *Streptocarpus*. The cotyledons are quite normal for some time after germination. They are small or even minute, orbicular, entire, sessile, and thinly glandular-hairy, or they develop a very short petiole and become roundly ovate or triangular, showing a midrib, but no other venation. The different stages of growth after germination are well shown by a seedling from *S. Rexii* crossed with *S. lutea* (fig. 568). There are two or not infrequently three cotyledons. The first leaf is developed from one of them by intercalary growth which sets in at the base of the lamina and continues for a considerable time. The original and true lamina of the cotyledon is carried up on the apex of the leaf, and the tip is therefore the oldest part. Finally it withers and dies away, and the apex of the leaf dies away from above downwards in the same fashion. In the early stage the leaf as a whole becomes obovate, then broadly ovate and obtuse. It retains this shape for some time; but ultimately becomes oblong or strapshaped with a more or less cordate base, attaining a length of six to ten inches or more. This type of *Streptocarpus* develops a rosette of leaves, the second one of which seems to arise from the short, thick and fleshy petiole of the first. *S. Rexii* var. *floribundus* is a strong-growing form of the species. In its early stages it behaves in the same way as the last, the first leaf being developed from one of the cotyledons by intercalary growth at the base. A rosette of leaves is ultimately formed, and when the plants are strong the leaves vary from six to twelve inches or more in length. The cotyledons of *S. Dunnii* are also perfect and normal in the early stages, small, rotund and entire. The only leaf the plant produces is developed from one of the cotyledons and becomes oblong, narrowed toward the apex, incurvi-penninerved, lobulate and dentate, cinereous above from the presence of grey hairs, and rusty beneath with reddish ones; it varies from twelve to thirty-six inches in length, and nine to twenty inches in width at the broadest part.

*Gesnera macrantha*, Spr.

*Primary root* slender, terete, apparently branching little if at all, and soon superseded by strong branching lateral rootlets abundantly furnished with root-hairs, all orange-red.

*Hypocotyl* short, globose, fleshy, pale reddish, increasing rapidly, and losing its epidermis which becomes rent into longitudinal stripes, 2-4.5 mm. in diameter sixty-six days after sowing the seed, forming the persistent rootstock of the plant.

*Cotyledons* very small, broadly ovate or triangular, obtuse, entire, petiolate, glandular-pubescent on both surfaces, and ciliate, pale green with a midrib discernible at the base only by transmitted light; lamina suddenly narrowed into the petiole, apex obtuse, 2.25-2.5 mm. long and the same in width; petiole about 1-1.25 mm. long.

*Stem* herbaceous, erect, terete, densely glandular-hairy, or almost villous, dying down annually to the persistent tuberous rootstock; 1st internode .5-1 mm. long; 2nd and 3rd similar.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, alternately incurvinerved with the nerves more or less united at their apex or forming intramarginal not very conspicuous reticulations, softly hairy or villous especially on the upper surface with shaggy whitish hairs; petiole semiterete, channelled above, densely hairy or villous with more or less glandular hairs.

First pair of leaves small, broadly ovate or rotund-ovate, obtuse, entire, with a midrib and a few alternate incurved nerves.

Second pair much larger, oval or rotund-elliptic, obtuse, entire or obsoletely crenate-dentate, with a more evident venation.

Third pair cordate-ovate, obtuse, crenate.

*Streptocarpus Rexii*, Lindl.,  $\times$  *S. lutea*, C. B. Clarke (fig. 568).

*Primary root* slender, tapering, with a few lateral rootlets.

*Hypocotyl* extremely short and fleshy, merging into the root, or hardly developed.

*Cotyledons* small, rotund, shortly petiolate, subtruncate at the base, apparently nerveless, light green, thinly hairy; lamina about 1.5 mm. in diameter; petiole 1 mm. long.

One of these cotyledons afterwards becomes the first true leaf and is very persistent, attaining a large size. The other one persists for some months but never gets larger.

The above is the usual origin of the first leaf, but seedlings frequently occur having three cotyledons; from one of which the first leaf is produced apparently at right angles to the others which soon cease to enlarge.

*Stem* very short, fleshy, becoming swollen and tuberous, appear-



ing continuous with or forming a petiole to the first leaf, and carrying it above the other cotyledon.

*Leaves* few, simple, radical, alternate, exstipulate, sessile, alternately and ascendingly penninerved, densely hairy on both surfaces, but especially so on the nerves beneath, with fleshy, crystalline, bulbous-rooted hairs.

No. 1. Originally ovate, obtuse, entire, apparently nerveless, afterwards alternately penninerved, becoming oblong, and crenate,

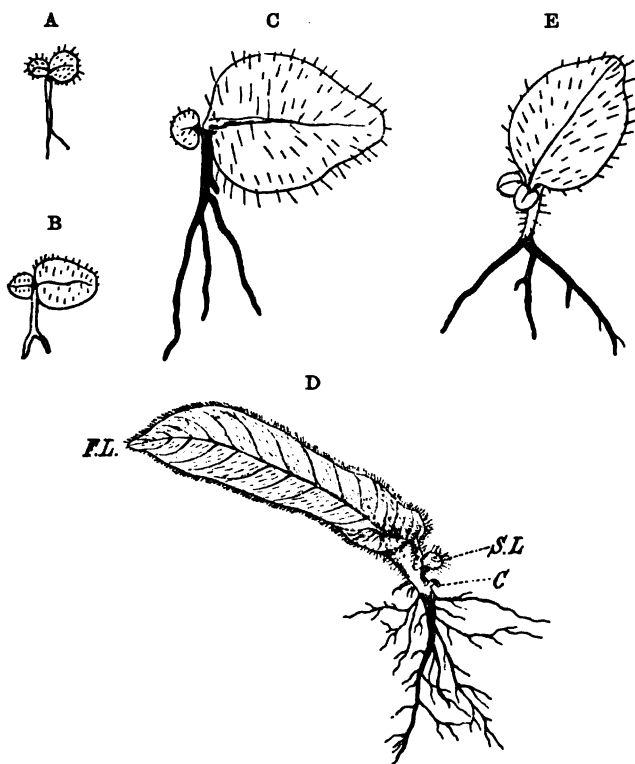


FIG. 568.—*Streptocarpus Rexii*  $\times$  *S. lutea*. A, B, C, different stages of seedling,  $\times 5$ . D, older seedling, nat. size: FL, first leaf; SL, second leaf; C, persistent cotyledon. E, Seedling with three cotyledons, from one of which the first leaf is developed,  $\times 5$ .

then panduriform by a wide development near the base, below which it is cordate and suddenly cuneate to the stalkless base, obtuse at the tip and thinly hairy denoting the persistence of the cotyledon, subrugose, with the primary nerves sunk above, prominent beneath and not terminating directly in the teeth.

No. 2. Originating at the very base of the first one, and opposite or oblique to it.

*Streptocarpus Dunnii*, Hook. f.

*Cotyledons* perfect and normal after germination, rotund, entire, growing until they reach a certain size (still very small) when one ceases and the other develops into a large leaf as described below.

*Stem* very short, fleshy, and scarcely distinguishable from the base of the leaf.

*Leaf* developed from one of the cotyledons, solitary, radical, simple, ovate, elongate, obtuse, obscurely crenate, very persistent and becoming large, ovate, acuminate, obtuse, cuneate at the base, but compressed there and appearing cordate where it suddenly widens, lobulate, ultimately oblong, coarsely dentate, alternately penninerved, the nerves not entering the lobes directly, but uniting with a strong branch of the nerve immediately above, and forming a span which is less than a right angle, reticulate, rugose, fleshy, densely covered with short fleshy adpressed pale grey hairs with a few reddish ones intermixed, cinereous above, rufous beneath from the intermixture of pale and red hairs, with prominent projecting nerves and prominently reticulated.

Ultimately the leaf is oblong, obtuse, slightly narrowed upwards, tapering at the base and appearing cordate by the contiguous sides, doubly dentate or lobular-dentate with gland-tipped teeth, alternately incurvi-penninerved, strongly rugose and reticulate, glandular-pubescent on both surfaces, cinereous above, rufous or reddish beneath, twelve to thirty-six inches long and nine to twenty inches at the broadest.

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## BIGNONIACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1026.

*Fruit and Seed*.—The ovary is superior, two-celled, with two parallel, distant or contiguous, but distinct placentas, adnate to the septum, but sometimes though rarely one-celled with two parietal bifid placentas. The ovules are numerous, horizontal, anatropous, and arranged in a single series or rather irregularly in one to many series. The fruit is capsular, dehiscing along the middle of the carpels or breaking away from the septa; or it is fleshy, indehiscent and more or less filled with fibrous, spongy or pulpy placentas. The seed

is transverse to the longitudinal axis of the fruit, and inserted on either margin of the septa in one or many series or scattered over the septa or drawn-out placentas. It is more or less compressed vertically, often flat, and often girt with a hyaline, rarely opaque wing which is broad, narrow or interrupted in many cases at the base and apex. The testa, in the centre of the wing is membranous or leathery, sometimes thickened, and at the apical end of the seed or at the chalaza it is intruded or pushed into the cavity of the seed, sometimes almost dividing it into two cells, thus accounting for the very prevalent bifid character of the cotyledons. Endosperm is wanting. The embryo is flattened or rarely thickened, with flat or rarely folded, bifid, emarginate or rarely entire cotyledons, which are often broader than long. The radicle is always short, often very short, and horizontal. Some exceptions occur in the Order, as in *Eccremocarpus* and in the *Crescentiæ* where the ovary is one-celled with two parietal placentas. The fruit is often abnormal in various ways in the tribes *Jacarandæ* and *Crescentiæ*, and is subfollicular in *Amphicome* and *Incarvillea*. The seed is furrowed or the testa partly invaginated in species of *Stereospermum*, and perfectly intruded between the cotyledons in *Kigelia*. The seeds are few and thick in *Argylia*.

All the seeds noticed are much flattened and winged ; they may be divided into those which have the wing continuous round the apex of the seed, and those in which it is absent at the base and apex. *Dolichandrone Cauda-felina* is the only typical instance of the latter observed. The seed is oblate, perfectly straight at the base and apex, while the testa is produced into a wing at either side, and obliquely truncate at the two ends. The portion of the seed containing the embryo occupies the whole of the centre. This peculiar form of the seed is due to that of the fruit which is a long, narrow pod with the seed occupying the whole width of the cavity. The embryo is large, nearly as wide as the seed, and is oblate, with the cotyledons deeply emarginate or shallowly bifid at the apex. The lobes are rounded in conformity with the seed, and the extremely short radicle occupies a shallow basal notch. The latter is due to the

presence of the radicle which has to be accommodated. The apical emargination or fissure is due to the intrusion of the testa at that point where the chalaza is situated, as explained under *Bignonia speciosa*. *Catalpa speciosa* most nearly approaches to the above, inasmuch as the seed is oblate and strongly winged at either end, but the wing is continuous at the apex, though not very wide, and is also continuous at the base except for a deep notch at the hilum. It is deeply fringed or lacerated at either end. The greatly widened seed and its short longitudinal axis are due to the narrowness of the long, slender, cylindrical fruit. The embryo is oblate and much constricted in the middle, almost dividing the cotyledons into two equal suborbicular portions. The radicle occupies one notch.

A good type of a seed with a continuous wing is furnished by *Pithecoctenium Aubletii*. The thickened portion of the testa containing the embryo is not central, and the really membranous portion is absent at the linear or oblong hilum. The embryo is oblate, deeply constricted in the middle with open notches and an extremely short radicle. *Oroxylum indicum* is another instance of a broadly winged seed, and the wing is slightly but irregularly dentate at the margin. The embryo differs from that of the last by having the lobes imbricated at the apical fissure, almost hiding the latter. The radicle is deeply seated in the basal notch which is otherwise open. The fruit of *Bignonia speciosa* is oblong, flattened and densely covered with tubercular spines or emergences. The seeds are arranged in two rows in each cell upon widely separated placentas, and are much imbricated, the lower ones always overlapping the upper. They are oblate and broadly winged; and the embryo is constricted in the middle with rather wide notches. *Bignonia insignis* differs by having its cotyledons fleshy, amalgamated in one piece, and subterranean even after germination. The embryo, however, conforms in shape to the other species in all general particulars. *Pajanelia multijuga* has rather narrowly winged seeds. The embryo is deeply bifid at the apex but hardly notched at the base, while the radicle is inconspicuous. It is not central. This also occurs in *Stereospermum suaveolens*, but the wing is broader at each side

than it is at the base or apex of the seed. The embryo is similar to that of the last.

The fruit of *Incarvillea Olgæ* is a linear, slender and terete capsule. The seeds are pendulous in two rows, and imbricated, the uppermost being outermost; they are also numerous and small. The wing is continuous except at the base. The embryo is central or nearly so, with oval, shallowly emarginate cotyledons distinctly auricled at the base. The radicle projects considerably beyond the base of the auricle. The fruit of *Eccremocarpus scaber* is an inflated capsule ovate-oblong in outline. The seed is orbicular and compressed with the wing continuous round the margin except at the hilum where there is a small notch. That part of the testa in which the embryo is situated is black and obovate in outline. The embryo is broadly obovate or oblate in outline when mature, and the cotyledons are suborbicular and entire. The oblate outline is more developed after germination. This species is one of the few cases occurring in the Order of a one-celled ovary with two parietal placentas.

*Seedlings*.—About half a dozen different types of cotyledons have come under my notice, but only one of them is of very frequent occurrence, and most of the others are more or less evidently modifications of it. This leading type may be represented by *Catalpa Kämpferi* (fig. 571). The cotyledons are oblate and deeply bifid with rounded entire diverging lobes. The midrib terminates in the sinus, and represents the real length of the lamina. The lobes are lateral developments dependent upon the shape of the seed, and that again is due to the shape of the capsule which is long, narrow, subcylindrical and pod-like. The seeds being inserted on the placenta at right angles to the longitudinal axis of the capsule, they attain a larger size than they otherwise could, by growing in breadth. The cotyledons therefore develop the lateral lobes, which gives them their characteristic form, in order to occupy the additional space afforded them, right and left of their longitudinal axis. The cotyledons of *C. syriacæ* are divided nearly to the base of the lamina. Those of *C. speciosa* are not quite so deeply divided, but are otherwise similar and show the venation. They are trinerved from the base,

and the lateral nerves run down the centre of the lateral lobes, giving off a few strong branches. The midrib forks or gives off two lateral branches close beneath the sinus, and these pass along the contiguous edges of the lobes a short way within the margin. The first pair of leaves of *C. Kämpferi* are ovate followed by two subcordate pairs. All the three pairs in *C. syringæfolia* are cordate. The first pair in *C. speciosa* are subcordate followed by three cordate pairs. In all cases these primary leaves are slightly dentate. The ultimate leaves are entire or sometimes shallowly trifid in *C. Kämpferi*.

The cotyledons of *Tecoma stans* closely correspond to those of *Catalpa syringæfolia* and are also trinerved. The first five pairs of leaves are however lanceolate, acuminate and sharply serrate. The cotyledons of *Tecoma Manglesii* are similarly divided, but without discernible venation in the fresh state, and the lobes overlap one another at the sinus. The first pair of leaves are small, ovate and entire. The second pair are digitately trifoliolate, and the third pair pinnately trifoliolate, both with more or less toothed leaflets. The fourth and fifth pairs have five leaflets; the sixth and seventh have seven leaflets; and the eighth and ninth have nine. The cotyledons of *Spathodea adenophylla* may be compared with those of *Tecoma stans*. The first pair of leaves are oblong-lanceolate and serrate.

A slight modification of the above is met with in *Spathodea campanulata* (fig. 572). The cotyledons are oblate and shallowly bifid or deeply emarginate. An obscure midrib is the only venation apparent. The first three pairs of leaves are elliptic, serrated except in the lower third of their length, and hairy. *Tecoma radicans* differs only in showing three branching nerves in the cotyledons. Those of *Kigelia pinnata* have five branching nerves from the base. The hypocotyl is subterranean or very short; and the first three leaves are rather large, lanceolate-oblong and serrate. The cotyledons of *Eccremocarpus scaber* (fig. 574) are broadly emarginate with a tooth in the notch, trinerved at the base with a pair of strong lateral nerves about the middle, thinly glandular-hairy on both surfaces and glandular-ciliate. The hypocotyl is also finely glandular-pubescent. The first pair of leaves

are rotund and five- to seven-angled with a strong nerve running into each angle or tooth. The ultimate leaves are bipinnatisect.

*Crescentia Cujete* (fig. 575) represents a third type having broadly oblong-ovate, emarginate, three- or faintly five-nerved cotyledons. The first pair of leaves are elliptic, and the ultimate ones are greatly elongated and vary from linear-lanceolate to elliptic-lanceolate.

The cotyledons of *Pithecoctenium muricatum* (fig. 570) are triangular, slightly emarginate, and obsoletely trifold. The first two pairs of leaves are pinnately trifoliate with elliptic leaflets.

A fifth type is met with in *Incarvillea Olgæ* (fig. 573) which has triangular, emarginate cotyledons, truncate at the base and faintly multinerved or striated. The two first pairs of leaves are ovate with a few serratures about the middle. *I. compacta* differs in having reniform, trinerved, broadly and shallowly emarginate cotyledons. The first leaf is oblong, slightly emarginate, cordate at the base, but otherwise entire and unsymmetrical.

The sixth type occurs in *Bignonia insignis* (fig. 569) and is the only instance of the kind observed. The cotyledons are thick, fleshy, and amalgamated in one piece, and remain in the seed after germination, keeping fresh for many weeks even if they fail to germinate. The first pair of leaves are small and scale-like; the second, third and fourth pairs are cordate, foliaceous and simple; while the fifth pair have each a pair of leaflets and a terminal tripartite hooked tendril.

***Bignonia insignis*, Hort. (fig. 569).**

*Hypocotyl* undeveloped or short and subterranean.

*Cotyledons* oblate, more or less emarginate, deeply subterranean and remaining in the oblate winged seeds until these decay, shortly petiolate, with the petioles unequally developed to accommodate the exit of the plumule.

*Stem* in the early stages erect, terete, finely and minutely pubescent, pale, dull or brownish-green, sometimes rosy red, ultimately woody and climbing; 1st internode 2-2.4 cm. long; 2nd 8-14 mm.

*Leaves* cauline, opposite, decussate, exstipulate, petiolate, alternately incurvinerved and reticulate. glabrous except at the margin

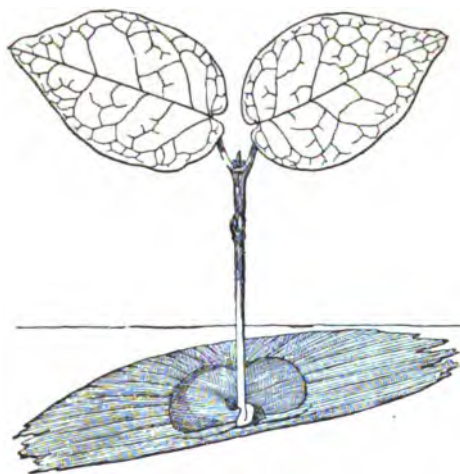


FIG. 569.—*Bignonia insignis*.  
Nat. size.

and on the principal nerves where they are shortly and minutely pubescent, deep green above, very pale or whitish beneath; petiole terete, with a slender channelled line on the upper side, densely and minutely pubescent, articulated with the stem, and slightly thickened at the insertion.

First pair of leaves reduced to lanceolate-acuminate, pale green, minutely pubescent scales.

Second and third pairs cordate-ovate, apiculate, entire, foliaceous.

Fourth pair simple but sometimes articulated with the petiole.

Fifth pair compound with one pair of leaflets, and terminating in a tripartite, slender, hooked tendril by which the plant is enabled to climb.

*Pithecoctenium muricatum*, Moc. (fig. 570).

*Hypocotyl* erect, terete, minutely pubescent, 1-1.6 cm. long, light green.

*Cotyledons* broadly ovate, obtuse, slightly emarginate, obsoletely and obtusely tri-lobed or -angular, increasing considerably in size after emerging from the seed, petiolate, minutely pubescent, dark green, five-nerved; petioles short, thin, pubescent, deeply furrowed on the upper face.

*Stem* erect, terete, herbaceous, ultimately woody, pubescent; 1st internode 8-10 mm. long; 2nd about the same.

*First leaves* cauline, opposite, compound, trifoliate, petiolate, exstipulate, pubescent; leaflets obovate-oblong, obtuse, entire or minutely emarginate, petiolulate, often unsymmetrical, ciliate, green, pinnatinerved; petioles long, thin, pubescent, channelled on the upper side.



**Catalpa Kämpferi**, Sieb. et Zucc. (fig. 571).

*Primary root* normal, tapering, flexuose, and abundantly furnished with lateral rootlets.

*Hypocotyl* woody, erect, terete, finely pubescent, purplish, 1–2 cm. above the soil.

*Cotyledons* deeply bipartite, with rotund, entire, divaricate segments; petiole somewhat flattened horizontally, or slightly convex on both surfaces, shallowly grooved above, finely pubescent; lamina glabrous, 7 mm. long, 13 mm. from tip to tip of the lobes.

*Stem* woody, erect, terete, finely pubescent, pale green or tinged with purple; 1st internode 11·5 mm. long; 2nd 8·5 mm.

*Leaves* simple, cauline, opposite, or verticillate in whorls of three, exstipulate, petiolate, pubescent above, at the margins and on the nerves beneath or all over, three- to five-nerved at the base (the two anterior of the basal four much the stronger and running into the side lobes of the leaf in the adult plant), rather dark green above, and stained with purple when unfolding, paler beneath; petioles of the first pair slightly grooved above, of the second pair flattened above, of the third pair terete or subterete, pubescent—of the adult leaves terete or sometimes slightly channelled on the upper half.

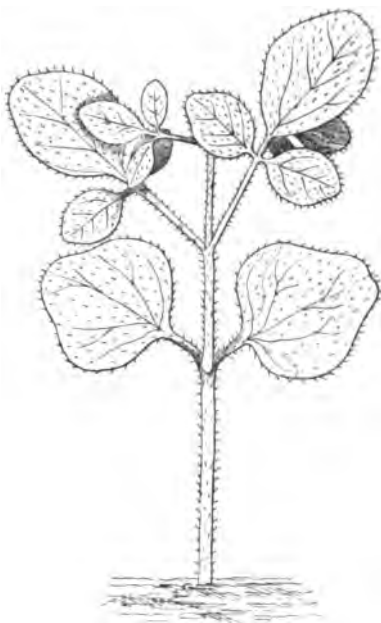


FIG. 570.—*Pithecoctenium muricatum*,  $\times 2$ .



FIG. 571.—*Catalpa Kämpferi*.  
Half nat. size.

First pair ovate, obtuse, unequal at the base, with one or two obsolete teeth on each side.

Second pair ovate-cordate, obtuse, submucronate, five-nerved, and shallowly dentate in the lower half.

Third pair ovate, cordate, acuminate, five-nerved in the lower half and dentate along two-thirds of their length.

Ultimate leaves large, cordate, entire or triangular or shortly trifid above the middle, five-nerved at the base; lateral lobes small, triangular, obtuse or acuminate; middle lobe short, broad, triangular, suddenly acuminate.

***Catalpa syringæfolia*, Bunge, var. *speciosa*.**

*Hypocotyl* as in *C. Kämpferi*; 3 cm. above the soil.

*Cotyledons* very similar to those of *C. Kämpferi* but larger, trinerved at the base with the middle one terminating in the notch; lobes broadly obovate, 2 cm. long, 3.15 cm. from the tip of one to the tip of the other.

*Stem* sparingly pubescent and covered with lenticels, green, and purplish towards the base; 1st internode 2.65 cm. long; 2nd 2.7 cm.; 3rd 2.4 cm.

*Leaves* similar to those of *C. Kämpferi*, opposite, decussate.

First pair of leaves subcordate, acuminate, distantly and minutely dentate.

Second and third pairs cordate, acuminate, entire.

Fourth pair cordate, acuminate, distantly dentate on the lower half.

***Catalpa bignonioides*, Walt.**

*Hypocotyl* as in *C. Kämpferi*.

*Cotyledons* deeply bipartite nearly to the base of the lamina, glabrous except the basal part and both surfaces of the petiole; real length of the lamina about 8 mm.; lateral lobes 1.3–1.5 cm. long, 1–1.15 cm. wide; width across both lateral lobes 2.4–2.6 cm.; midrib ending below the sinus and giving off from each side two lateral nerves which run into the lobes and, uniting some distance below their apex, give off numerous smaller anastomosing branches; petiole cuneate, tapering to the base, grooved on the upper surface by the upturning of the edges, convex on the back, strongly trinerved, finely and densely glandular-pubescent or papillose, about 5 mm. long.

*Leaves* opposite, decussate, and ternately verticillate, unequal, alternately incurvinerved and reticulate, papillosely glandular on the nerves on both surfaces and margin, deep green above, paler

beneath; petioles subterete and shallowly grooved, or terete and obsoletely channelled above, glandularly papillose especially on the upper surface.

First, second and third pairs cordate, acute or subacute, unequal, entire.

***Tecoma stans*, Juss.**

*Hypocotyl* erect, terete, pubescent with short, spreading or deflexed hairs, green, about 1·6 cm. above the soil.

*Cotyledons* deeply bi-fid or -partite with rotund-obovate, divaricate lobes, trinerved with the middle nerve ending in the sinus, glabrous, pubescent at the margin, green above and covered with minute grey dots, very pale beneath, tapering into the petiole; lamina 1·2 cm. long, 2·2 cm. from the tip of one lobe to that of the other; petiole grooved above, tapering to the base.

*Stem* erect, terete, green, pubescent; 1st internode 9·2 cm. long; 2nd 1·1 cm.; 3rd 7 mm.; 4th 8 mm.

*Leaves* simple, ultimately compound, cauline, opposite, decussate, exstipulate, petiolate, glabrous, shining, penninerved with alternate, ascending nerves, subincurved towards their apex; petioles semi-terete, deeply channelled above, sparingly pubescent.

First and second pairs lanceolate, incise-serrate.

Third and fourth pairs lanceolate, acuminate, cuneate at the base, incise-serrate.

***Tecoma Manglesii*, ? Hort.**

*Hypocotyl* very short.

*Cotyledons* small, deeply bi-lobed or -partite; lobes oblate, overlapping without any discernible venation, minutely pubescent on the upper side; lamina ·75–1·25 mm. to the base of the sinus; lobes about 4·5 mm. long and 6 mm. wide; petiole about ·5 mm. long.

*Stem* erect at first, rather acutely quadangular, pale green and straight for the first five nodes, above which it commences to twist and then to twine, glabrous except at the nodes where the bases of the petioles are connected by a ridge furnished with hairs, purple above the fifth node; 1st internode 1·75 mm. long; 2nd 3·25 mm.; 3rd 1·1 cm.; 4th 1·45 cm.; 5th 2·15 cm.; 6th 3·25 cm.; 7th 5·15 cm.

*Leaves* compound, imparipinnate (first pair simple), cauline, opposite, exstipulate with a horizontal rim or plate connecting the bases of the petioles, scaberulous on both surfaces, deep green and

shining above, paler beneath or glaucous; rachis of leaf narrowly winged; leaflets articulated with the rachis, alternately penninerved with the nerves incurved at the top and uniting one with another forming a few large reticulations; petiole semiterete, rather deeply grooved above, or very narrowly winged at the edges, thinly pubescent.

First pair of leaves small, ovate, obtuse, simple, entire.

Second pair digitately trifoliolate; lateral leaflets obovate, slightly crenate or entire; terminal one elliptic, crenate-dentate, tapered to the base.

Third pair pinnately trifoliolate; lateral leaflets cuneate, coarsely and obtusely dentate; terminal one rhomboid, shallowly lobulate or coarsely dentate.

Fourth pair pinnately five-foliolate; lateral leaflets cuneate, the terminal one elliptic, all coarsely dentate, undulate at the margin.

Fifth pair similar but larger.

Sixth and seventh pairs seven-foliolate; lateral leaflets rotund, cuneate, flat, irregularly crenate or obtusely dentate.

Eighth and ninth pairs pinnately nine-foliolate; lateral leaflets cuneate, crenate, often almost entire; terminal one lanceolate-elliptic, obtuse.



FIG. 572.—*Spathodea campanulata*.  
Nat. size.

***Spathodea campanulata*,  
Beauv. (fig. 572).**

*Hypocotyl* 1–2 cm. long, 2–3 mm. thick, woody, terete, glabrous, greyish.

*Cotyledons* nearly equal, 1.5 cm. long including the short petiole, 1.25 cm. wide, broadly oblate, shortly bifid with the apex of the two short lobes rounded, glabrous, light green, rather caducous; midrib obscure.

*Stem* with internodes 5 mm. long, 2 mm. thick, terete, pubescent, green with white bands.

*Leaves* simple in the early stage of the seedling, ultimately compound, pinnate, cauline, opposite, exstipulate, petiolate, alternately and ascendingly penninerved, hairy; early leaves simple and serrate; leaflets of the leaves of adult plants said to be entire.

First pair elliptic, irregularly serrated, with sunk midrib, penni-

nerved, shortly petiolate, hispid or slightly scabrous, membranous, not very persistent.

Second, third and fourth pairs inclusive or a smaller number, similar but larger.

Fifth pair with one or two small leaflets at base of blade quite or partly detached.

Sixth pair pinnate.

***Incarvillea Olga*, Regel (fig. 578).**

*Hypocotyl* erect, terete, glabrous, pale green, 1-1.7 cm. long.

*Cotyledons* triangular, obtuse, shallowly emarginate, truncate at the base, obscurely and alternately incurvinerved, deep opaque green, petiolate; lamina 5-6 mm. long, 4-7 mm. wide; petiole slightly channelled above, glabrous, almost biconvex, connate at the base, 6-10 mm. long.

*Stem* herbaceous, erect, terete, glabrous, pale green or stained with red; 1st internode 2.75 mm. long; 2nd 4 mm.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, alternately penninerved, glabrous, deep green above, paler beneath, shining on both surfaces; petioles semiterete, glabrous, channelled above, subconnate at the base.

First pair ovate, obtuse, minutely cuspidate, with one to two small serratures on each side, about the middle.

Second pair similar, but more acutely cuspidate.

***Incarvillea compacta*, Maxim.**

*Hypocotyl* short, not appearing above the soil.

*Cotyledons* almost reniform, broadly cordate at the base, emarginate, obtuse, with long petioles, fleshy, dark green, glabrous, indistinctly trinerved.

*First leaves* simple, radical, alternate, minutely emarginate, cordate at the base, oblong, unsymmetrical, one side of the leaf extending farther down the petiole than the other, exstipulate, with very long petioles, bright green on the upper side, subglaucous beneath, glabrous, pinnatinerved.

***Eceremocarpus scaber*, Ruiz et Pav. (fig. 574).**

*Primary root* slender, fibrous, giving off lateral branches.

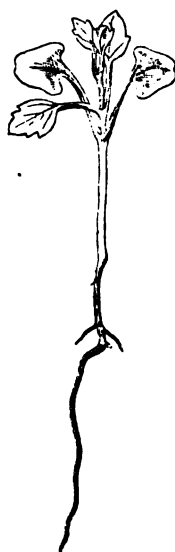


FIG. 578.  
*Incarvillea Olga*.  
Nat. size.

*Hypocotyl* erect, terete, glandular-pubescent, almost colourless, 1-1.8 cm. long.

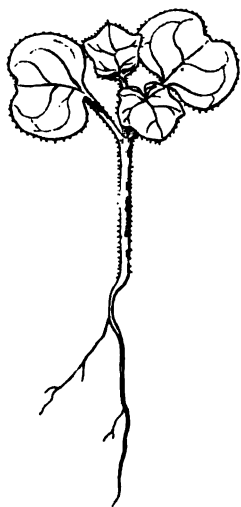


FIG. 574.  
*Eccremocarpus scaber*,  $\times 2$ .

*Cotyledons* subreniform, deeply and broadly emarginate with a mucro in the sinus, two alternate incurved nerves on each side, thinly glandular-hairy on both surfaces and glandular-ciliate; lamina 4-5 mm. long, 6-7.5 mm. wide; petiole semiterete, decurrent on the hypocotyl or subconnate, glandular-pubescent, channelled above, 3-4.5 mm. long.

*Stem* herbaceous, slender, erect, ultimately climbing; 1st internode .5-1 mm. long.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, alternately penninerved, glandular-hairy on both surfaces, bright green; petioles semiterete, channelled above, somewhat dilated at the base, glandular-hairy.

First pair rotund, obtuse, five- to seven-angled or -toothed, with a strong nerve entering each tooth, which is tipped

with a mucro.

Ultimate leaves bipinnatisect and terminating in a simple or branched cirrhous, by which the plant is enabled to climb.

#### *Crescentia Cujete*, L. (fig. 575).

*Hypocotyl* erect, terete, minutely and finely pubescent, pale green, 1.5-1.8 cm. above the soil.

*Cotyledons* broadly ovate-oblong, very obtuse, rather deeply and narrowly emarginate, appearing subcordate from a sudden curvature at the base of the lamina, petiolate, trinerved with a few short alternate nerves directed upwards, light green above, paler beneath, glabrous; lamina 1.2-1.35 cm. long, 1.15 cm. wide; petiole with a shallow furrow on each side of a median ridge, minutely pubescent, pale green, connate at the base, ascending and bearing the lamina horizontally; 4 mm. long.

*Stem* erect, subterete in a very early stage with a shallow furrow on two sides, very shortly pubescent, pale green, ultimately woody, with a pale-coloured, rough and knotty bark; 1st internode 8-10 mm. long.

*Leaves* simple, cauline, entire, fascicled or opposite on the seed-

ling, exstipulate, shortly petiolate or almost sessile, alternately incurvined, deep green above, paler beneath, with the nerves sunk on both surfaces, obscurely reticulate, glabrous; petiole very short or almost absent, grooved on the upper side by the decurrent margin of the leaf.

First pair of leaves obovate-elliptic, tapered to the base, obtuse and tipped with a small mucro.

Ultimate leaves irregularly grouped or fascicled, lanceolate, oblong-lanceolate, linear-lanceolate or elliptic-lanceolate, very variable in length, generally much tapered to both ends, obtuse, alternately penninerved, with the nerves incurved and giving off recurved branches, forming an arch, and in all cases uniting with one another, and anastomosing some distance within the margin, much punctate beneath, decurrent almost to the very base, reducing the petiole to its much thickened base.



FIG. 575.—*Crescentia Cujete*.  
Nat. size.

## PEDALINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1054.

*Fruit and Seed.*—The ovary is superior, sometimes one-celled with two parietal placentas each divided into two lamellæ projecting into the cavity; sometimes two- rarely three- or four-celled with the cells undivided, or in other cases subdivided by spurious septa or ingrowths from the wall. The ovules are solitary in each cell or numerous and superposed in a single series, horizontal, ascending, pendulous, or erect from the base and anatropous. The fruit is capsular, nut-like, or more rarely subdrupaceous, with a fleshy endocarp. The endocarp as well as the placentas or even the whole

fruit becomes very much hardened at maturity, and is often also prickly, dehiscing loculicidally by two valves at the apex or almost throughout its length or it is indehiscent. Internally it is two-celled or divided into locelli twice as numerous as the carpels. The seeds vary in number as the ovules, arise from the inner angles of the cells, and are obovate, oblong, or orbicular and often compressed. The testa is smooth or depressed into little areolæ, and sometimes though rarely it is expanded into a hyaline wing. As endosperm is wanting, the embryo conforms to the seed and has flat or plano-convex somewhat fleshy cotyledons, with a short straight radicle close to the hilum.

The seeds of *Sesamothamnus* are compressed or flattened and winged ; in some species of *Sesamum* they are also somewhat compressed and narrowly two-winged.

The ovary of *Martynia proboscidea* consists of two carpels, and is one-celled with numerous ovules superposed on two parietal placentas. The fruit is somewhat baccate, but ultimately dehiscent. The seed is obovate, compressed and rugose, with the external coat very much thickened and hardened. The inner coat is membranous, hugs the embryo pretty closely, and is shorter, as a rule, than the testa when the seed is dry, leaving an empty space at the end next the hilum. The embryo is straight with obovate, three- or faintly five-nerved cotyledons slightly auricled around the radicle, and shallowly emarginate owing to a thickening at the chalaza.

*Seedlings*.—The seedlings of *Martynia* are glandular-hairy all over and notable for their great size, particularly for the length of the hypocotyl. The cotyledons of *Martynia fragrans* are roundly oblong, broadly and shallowly emarginate, and auricled at the base, with several ascending branching nerves on each side of the midrib. The first pair of leaves are oblong-oval, much smaller than the cotyledons, and like them densely and coarsely glandular-hairy. The cotyledons of *M. proboscidea* are comparatively narrower than the last, and oblong, deeply auricled at the base, and five-nerved. They fall away rather early. The leaves are opposite and densely glandular-hairy. The first pair are oblong-cordate and five-nerved. The second pair are roundly cordate and five-



nerved, while the third pair are similar but very much larger and five- to seven-nerved.

**Martynia proboscidea, Gloxin.**

*Pistil* surrounded at the base by a disc ; ovary one-celled, many-ovuled ; ovules pendulous, anatropous ; radicle superior.

*Fruit* a subdrupaceous or rather sub-baccate capsule, one-celled, with two broad or lamellate parietal placentas, many-seeded, dehiscent loculicidally. It terminates in two long curved horns, which attach themselves to animals and so disseminate the plant. I have already figured it in 'Flowers, Fruits and Leaves' (fig. 51).

*Seed* obovate, dorso-ventrally compressed, rugose and raised into numerous short, blunt projections round the margins, but especially of the upper half ; testa thick, cortical, rough, black ; tegmen thin, almost membranous, white ; hilum close to the apex on the ventral aspect, forming an open cavity when dry ; micropyle basal and contiguous to the hilum ; chalaza more or less prominent and thickened externally, and also forming a more or less evident thickening on the inner coat, most evident when moist and discoloured.

*Endosperm* absent.

*Embryo* straight, large, obovoid, dorso-ventrally compressed, conforming closely to the tegmen, colourless ; cotyledons obovate, plano-convex, emarginate at the chalaza, three- or indistinctly five-nerved from the base upwards, thick and fleshy, auricled at the base to fill the seed while accommodating the radicle ; radicle very stout, blunt, turbinate, short and only slightly protruded beyond the cotyledons.

**Seedling.**

*Primary root* tapering downwards, with numerous lateral rootlets immediately at the base of the hypocotyl, brownish-orange, annual.

*Hypocotyl* erect, terete, densely glandular-hairy or pubescent, pale green, stout, fleshy, 6 cm. long.

*Cotyledons* large, oblong, obtuse, cordate or auricled at the base, coarsely hairy on both surfaces, petiolate, dull green ; lamina 2 cm. long, 1·3 cm. wide ; petiole channelled above, about 2 cm. long.

*Stem* herbaceous, annual, stout or fleshy, erect, terete, pale green, densely glandular-hairy ; 1st internode 2·35 cm. long ; 2nd 1·8 cm. ; 3rd 1 cm. ; 4th 9 mm.

*Leaves* simple, cauline, opposite, decussate, exstipulate, petiolate, five- to seven-nerved with ascending, slightly incurved nerves, reticulate, densely glandular-hairy all over, viscid, odoriferous, dull green ;

petioles subterete, narrowly channelled above, stout, tapering towards the apex, densely glandular-hairy, pale green.

First pair oblong-cordate, obtuse, entire, slightly wavy at the margin, five-nerved.

Second pair rotund-cordate, obtuse, entire, five-nerved; three of the nerves spring directly from the apex of the petiole and are naked, that is without parenchyma on the sides at the base.

Third pair rotund-cordate, obtuse, five- to seven-nerved, obscurely and distantly dentate at the apex of the principal nerves and veins; three principal nerves as in the second pair.

Fourth pair with closed or overlapping auricles at the base, and more decidedly dentate at the apex, otherwise like the third.

***Martynia fragrans*, Lindl.**

*Hypocotyl* as in *M. proboscidea*, densely glandular-hairy, 7-10.5 cm. long.

*Cotyledons* somewhat fleshy, broadly oblong or subrotund, emarginate, auricled at the base with a long channelled petiole, covered with glandular hairs, pinnatinerved as in the leaves.

*Stem* as in *M. proboscidea*; 1st internode 1-1.2 cm. long.

*First leaves* opposite, oval-oblong, obtuse, shortly petiolate, ciliate, covered with glandular hairs, light green, pinnatinerved.

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## ACANTHACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1060.

*Fruit and Seed*.—The ovary, consisting of two carpels, is superior, two-celled, and undivided. The ovules are collateral in pairs in each cell of *Thunbergia*; in the tribe *Nelsoniæ* they are numerous and superposed in a double series; and in all other tribes they vary from two to many, but seldom exceed eight, and are arranged in a single series or alternately one above the other. In all cases they are anatropous or shortly amphitropous. The fruit is a capsule (except in *Mendoncea* where it is one-seeded and drupaceous), globose, oblong, oblong-linear, terete or compressed in various ways, equal from the base upwards, or contracted at the base forming a solid, seedless stalk. It dehisces loculicidally from the apex to the base, including the solid, seedless portion, and often bursts elastic-

ally with some force, the valves carrying with them the seed-bearing half-placentas. The seeds vary in number as the ovules, but are frequently fewer by abortion. In *Thunbergia* and in the tribe *Nelsoniæ* they are globose or orbicular and dorsally compressed with a ventral hilum. In other tribes they are laterally compressed and ascending, with the hilum basal and marginal. The funicle is hardened and incurved, forming the hook-like process (retinaculum) upon which the seed is borne; sometimes this hook is produced beyond the point of attachment to the seed. The testa is membranous or thickened, often variously corrugated or raised into little points; it is sometimes smooth or covered with mucilage which when dry forms a covering resembling adpressed hairs. Endosperm is wanting except in the species belonging to the tribe *Nelsoniæ*. In other groups the embryo occupies the whole of the interior of the seed, and conforms to its cavity. The cotyledons are orbicular, flat or plano-convex, and cordate at the base. The radicle is short and straight or bent obliquely to the axis of the cotyledons, and occupies the basal notch of the latter.

The ovule, embryo and seed are often variously abnormal in the tribes *Thunbergiæ*, *Nelsoniæ* and the subtribe *Andrographidæ*. The ovules for instance of *Thunbergia fragrans* are amphitropous; the seeds are orbicular, dorsally compressed and concave on the ventral face where the hilum is situated. The embryo occupies the whole interior of the seed and is concave on the ventral aspect in conformity with the seed. The cotyledon on the ventral aspect has its edges recurved, partly covering the outer one on the dorsal aspect.

About four other types have come under my observation. The ovules of *Acanthus spinosus* are amphitropous or semi-anatropous and twin in each cell. The embryo is transversely oval and slightly emarginate in a young state, gradually becoming more orbicular as it reaches maturity, and the radicle is wholly included between the close-fitting auricles of the cotyledons. This is better seen in the longitudinal section of the seed of *A. longifolius* (fig. 579) which has transversely oval cotyledons somewhat indented near the chalaza, and deeply auricled around the radicle. They are plano-

convex, with the radicle nearly on the opposite side of the seed from the hilum.

A very common type is represented by *Strobilanthes callosus* which has orbicular nearly flat five-nerved and reticulated cotyledons, deeply and unequally auricled at the base, nearly concealing the radicle. The latter is terete and in its lower half curved round one edge of the cotyledons. The seed is slightly and obliquely indented at its insertion on the retinaculum. The cotyledons are shortly petiolate while yet in the seed ; but the strong auricles spread out and partly disappear after germination.

*Ruellia longifolia* (fig. 577) differs from the last in having a straight radicle and equal or nearly equal auricles. The flat orbicular seed is not indented at the hilum, but is slightly prominent at its insertion on the retinaculum. It is also papillosely hairy round the margin, with hairs of a mucilaginous nature which swell in water. The seed of *Eranthemum leuconeurum* (fig. 580) is rotund-ovate, flattened and unsymmetrical, with a slight indentation above the base on one side. There is a little tubercle or elevation at the hilum, and the testa is produced into a little sac at the base to accommodate the radicle, which is not surrounded by the cotyledons. The latter are minutely auricled at the base, trinerved and reticulate. This peculiar conformation of the seed gives the cotyledons a cuneate outline which becomes much more apparent after germination. In the seedlings examined they were much more symmetrical than while yet in the seed, and slightly emarginate.

*Seedlings*.—The cotyledons in this Order are mostly if not always large in comparison with the size of the seed and foliaceous. Although always of simple types, they are exceedingly varied in form.

A somewhat frequent form, represented by *Dipteracanthus micranthus*, has suborbicular emarginate trinerved cotyledons shallowly but generally unequally auricled at the base. In this instance the hypocotyl is very short ; and the first pair of leaves are oval. The cotyledons of *Ruellia barbadensis* are five-nerved but otherwise similar. Those of *Hygrophila longifolia* are almost truncate at the base. The hypocotyl is

elongated ; and the first pair of leaves are lanceolate. Many others conform pretty closely to this type. A curious dimorphism of the leaves may be noted in *Asystasia coromandeliana*. The first two pairs of leaves are ovate, followed by others which become broader and shorter until they are almost rotund on the upper part of the plant. The leaves of the first pair produced on the primary branches are small, generally very unequal in size and obovate, emarginate, or broadly ovate and cuspidate, or one of the two may be small, orbicular and entire. Succeeding ones gradually assume the normal form.

Another type where the cotyledons are very much shortened and almost reniform is represented by *Blechum Brownei*. In this species they are emarginate, truncate at the base, but cuneate at their attachment to the petiole and five-nerved. The cotyledons of *Strobilanthes gossypinus* differ slightly in being entire, trinerved, larger and almost truncate at the base. The primary internodes are very short, and the two first pairs of leaves are broadly ovate, densely hairy, and overlap one another in a decussate manner. *Dipteracanthus prostratus* agrees with the last, but the cotyledons are five-nerved. The cotyledons of *Strobilanthes callosus* correspond more closely to the type ; they are deeply and widely cordate at the base, foliaceous, and measure 2·5–2·9 cm. long, by 4·2–4·4 cm. wide. The hypocotyl is of considerable length, and so are the primary internodes of the stem. This also applies to *Phayloopsis parviflora* (fig. 578) although in a less degree. The cotyledons have a rather longer, trinerved lamina than in *Blechum Brownei* ; and the primary leaves are ovate with finely incurved alternate nerves.

*Peristrophe speciosa* (fig. 583) represents a third type having obliquely obovate, cuneate, emarginate, trinerved cotyledons. The first pair of leaves are ovate with a well-marked, incurved, penninerved venation. The cotyledons of *P. bicalyculata* are similar but smaller and unsymmetrical. The first pair of leaves are lanceolate. In *Eranthemum leuconeurum* (fig. 581) the cotyledons are still smaller than the last, very slightly emarginate, and symmetrical or nearly so. The first two pairs of leaves are

very broadly oval. The cotyledons of *Thunbergia alata* (fig. 576) are rotund-oblong, entire, cuneate at the base and trinerved with long petioles, as the hypocotyl scarcely appears above ground. The first two pairs of leaves are triangular-hastate, slightly and irregularly dentate, five-nerved and suddenly decurrent upon the long petioles, forming narrow wings to them. *Asystasia coromandeliana* (fig. 582) differs in having unsymmetrically orbicular slightly emarginate cotyledons, suddenly tapering into their petioles. The leaves of first pair are ovate with an incurved anastomosing venation similar to that of *Peristrophe speciosa*. A very remarkable type is met with in *Thunbergia reticulata*; the cotyledons are unequal, orbicular, trinerved, cordate at the base and minutely denticulate at the margin, particularly the larger one which has a peculiar elevation in the centre. Another case of unsymmetrical cotyledons is met with in *Dicliptera resupinata* where they are oblong, emarginate, trinerved and rather deeply sinuated on one side or almost falcate. Those of *Justicia bracteata* are obovate-oblong, emarginate, trinerved, and somewhat reticulated. Another curious development in the same direction is met with in *Schwabea ciliaris*, which has oblong, emarginate, one-nerved, fleshy, shortly petiolate cotyledons. The hypocotyl is greatly elongated and finely hairy, as is the first internode of the stem. The first three pairs of leaves are lanceolate and penninerved with ascending nerves.

***Thunbergia alata*, Boj. (fig. 576).**

*Hypocotyl* short, terete, pale green, densely pubescent.

*Cotyledons* large, foliaceous, petiolate, deep green above, paler beneath, densely pubescent on both surfaces; lamina rotund-oblong, trinerved, subcuneate at the base, 2.6 cm. long, 2.5 cm. wide; petiole channelled above, pubescent, 2.7 cm. long.

*Stem* herbaceous, erect, ultimately twining, terete, thickened at the nodes, densely pubescent, green, purple at the nodes; 1st internode 1.7 cm. long; 2nd 6.5 cm.; 3rd 7.2 cm.; 4th 17 cm.; 5th 15 cm.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, softly and densely pubescent on both sides, ultimately rough and scabrous above, and deep green, paler beneath; petioles convex on both surfaces,

winged nearly to the base, pubescent, ultimately scabrous like the leaves.

First pair triangular-ovate, obtuse, truncate at the base and subhastate, irregularly dentate, five-nerved.

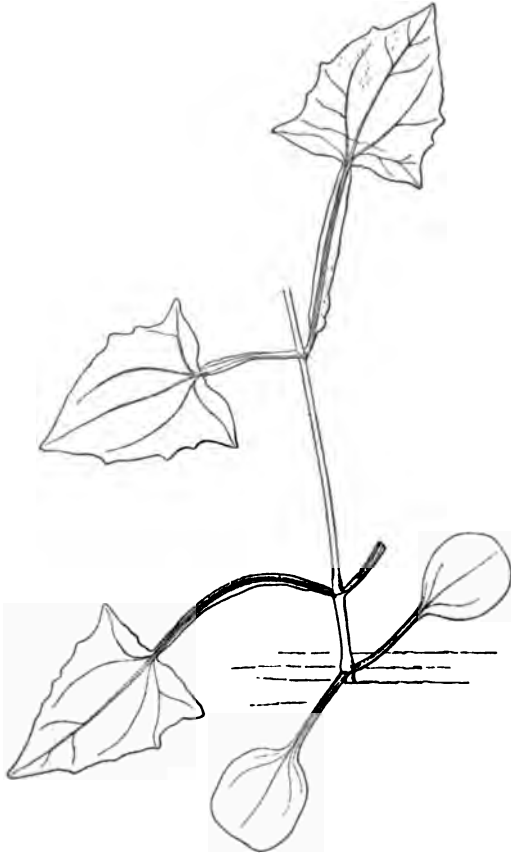


FIG. 576.—*Thunbergia alata*. Half nat. size.

Second and third pairs triangular-hastate, subcordate at the base, irregularly dentate, five-nerved.

Fourth and fifth pairs triangular-cordate, subhastate, slightly dentate or subentire, five-nerved.

***Thunbergia reticulata*, Hochst.**

*Hypocotyl* erect, terete, pubescent, 3–4 cm. long, green, with a reddish tinge.

*Cotyledons* simple, unequal, orbicular, obtuse, slightly emarginate, cordate at the base, the larger one slightly denticulate, the smaller one nearly or quite entire; the larger has also a raised portion in the centre caused probably by the funicle, which is central, petiolate, pubescent on the upper side, glabrous beneath; midrib with numerous lateral veinlets.

*Stem* erect, herbaceous in the seedling stage.

*First leaves* ovate, acute, simple, entire, opposite, cauline, pubescent or hairy, light green, reticulate.

The seeds are dorsally compressed; the cotyledons lying with their faces towards the hilum, which is very conspicuous, causing a deep indentation in the cotyledon, the one which is nearest the hilum being considerably thicker than the other, almost twice the thickness; the seed is exalbuminous.

### ***Hygrophila longifolia*, Nees.**

*Hypocotyl* erect, terete, with a few minute hairs, about 2 cm. long, tinged with red.

*Cotyledons* large, broadly oblong or almost triangular-rotund, obtuse, minutely emarginate, petiolate, glabrous except a few hairs on the petioles, dull green, alternately pinnatinerved as in the leaves, but more indistinctly.

Primary internodes of stem undeveloped.

*First leaves* simple, entire, radical, opposite, lanceolate, obtuse, ciliate, otherwise glabrous, petiolate, exstipulate, light green, distinctly pinnatinerved.

### ***Ruellia longifolia*, T. Anders. (fig. 577).**

*Ovary* stipitate, two-celled, many-ovuled (about six to eight in a cell); ovules erect or vertical, anatropous; radicle inferior.

*Fruit* a capsule, oblong, stipitate, dorsally compressed with a lateral groove and a slightly conspicuous dorsal midrib, tipped with the shortly conical persistent base of the style, glandular-pubescent, obtusely subquadrangular, dehiscing loculicidally.

*Seed* orbicular, laterally much compressed, lying in the hooked processes of the placenta which are given off right and left alternately, minutely reticulate or wavy on the flattened faces and papillose at the margin; hilum and micropyle contiguous, basal, inferior.

*Endosperm* in the full grown seed just before maturity, forming a thin, white layer, entirely surrounding the embryo

*Embryo* straight, conforming to the interior of the seed, large, colourless; cotyledons orbicular, flat, deeply auricled at the base,



three- or five-nerved, with the lateral nerves giving off two very strong branches from their posterior side at the base into the auricles which are large, deltoid, obtuse and slightly unequal, lying in the broad plane of the seed, and conforming in outline to its interior with their basal edges to the hooked process of the placenta, and their backs to the axis; radicle oblong-fusiform, tapered to an obtuse point and projecting about one-third of its length or less beyond the auricles, and having its tip close to the hilum and micropyle.

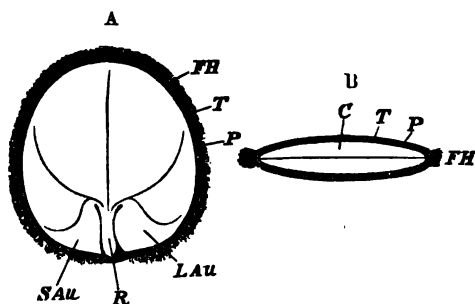


FIG. 577.—*Ruellia longifolia*,  $\times 10$ . A, longitudinal section of seed: SAU, smaller auricle; R, radicle; LAU, larger auricle; P, endosperm; T, testa; FH, fringe of hairs. B, transverse section of seed: C, cotyledon; T, testa; P, endosperm; FH, fringe of hairs.

***Ruellia barbadensis*, Benth. et Hook.**

*Hypocotyl* erect, terete, glabrous, 1.0–1.5 cm. long, light green or colourless.

*Cotyledons* suborbicular or almost reniform, obtuse, emarginate, petiolate, glabrous, light green, five-nerved, almost truncate at the base; petiole rather long, channelled on the upper side.

*Stem* erect, terete, pubescent, herbaceous; 1st internode 1.5–2 mm. long.

***Dipteracanthus micranthus*, Engelm. et Gray.**

*Hypocotyl* erect, terete, pubescent, 3–4 mm. long, light green or colourless.

*Cotyledons* broadly oblong, obtuse or triangular, entire or minutely emarginate, cordate at the base, petiolate with rather long petioles, glabrous except on the petioles, dark green, pinnatinerved, the lower nerves much longer than the others.

*Stem* erect, terete, herbaceous, ultimately woody, pubescent; 1st internode 4–5 mm. long.

*First leaves* simple, entire, cauline, opposite, exstipulate, oblong-oval, obtuse, shortly petiolate, ciliate, pubescent, light green, alternately pinnatinerved.

***Dipteracanthus prostratus*, Nees.**

*Hypocotyl* short, scarcely appearing above the soil.

*Cotyledons* oblate or almost reniform, entire, slightly auricled at the base, glabrous, green, five-nerved at the base ; petiole long, flat, hairy, channelled above.

*Stem* as in last species, but covered with long, dense, white hairs ; 1st internode 2-2.5 cm. long ; 2nd 3-4 cm. ; 3rd about 2 cm.

*First leaves* opposite, decussate, broadly lanceolate or elliptic, cuneate at the base, obtuse, shallowly crenate, ciliate, hairy ; petioles stout, hairy, almost flat, scarcely channelled above.

***Phayloopsis parviflora*, Willd. (fig. 578).**

*Hypocotyl* erect, terete, pubescent with decurved hairs, purplish, about 1.6 cm. above the soil.

*Cotyledons* semiorbicular, emarginate, truncate at the base or

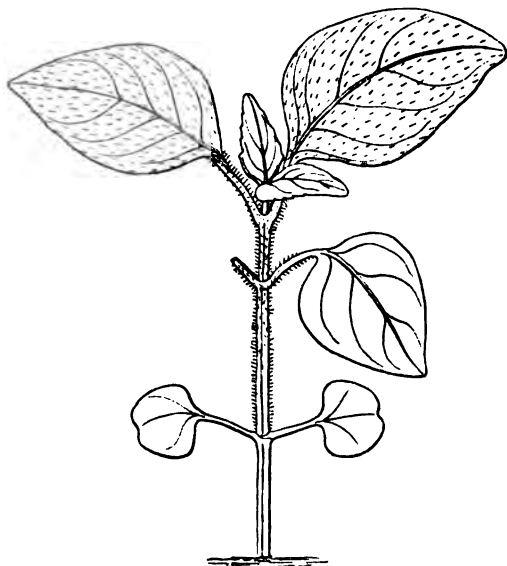


FIG. 578.—*Phayloopsis parviflora*. Nat. size.

tapering slightly into the petiole ; lamina glabrous, 7 mm. long 1 cm. wide ; petiole channelled above, pubescent, 7.5 mm. long.

*Stem* herbaceous, erect, quadrangular, somewhat thickened at the nodes, pubescent with short decurved hairs, and somewhat bearded

at the young nodes, purplish; 1st internode 2 cm. long; 2nd 1 cm. or more when fully developed.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, alternately incurvinerved, pubescent on both surfaces, deep green above, very pale or subglaucous beneath (at least when young); petioles convex on both surfaces, densely pubescent with upcurved hairs which are arranged in lines on the upper surface, slightly grooved on each side.

Hairs of leaves glandular at the base (at least when young).

First and second pairs broadly ovate, obtuse, entire, subcuneate at the base.

Third pair ovate, obtuse, shallowly dentate.

***Blechnum Brownei*, Juss.**

*Hypocotyl* erect, terete, hairy, 2-2.4 cm. long, light green or colourless.

*Cotyledons* oblate, obtuse, almost truncate at the base, entire or minutely emarginate, petiolate, slightly hairy, light green, five-nerved; petiole rather long, channelled on the upper face.

*Stem* erect, square, herbaceous, ultimately woody, pubescent; 1st internode 6-15 mm. long; 2nd shorter.

*First leaves* simple, entire, cauline, opposite, decussate, broadly ovate or oval, obtuse, exstipulate, petiolate, hairy and green above, minutely hairy and subglaucous-green beneath, pinnatinerved; petioles short, hairy, furrowed on the upper side.

***Strobilanthes callosus*, Nees.**

*Ovary* two-celled, with one ovule in each cell; ovule erect, anatropous, seated on the middle of a twice curved process of the placenta (retinaculum).

*Fruit* a capsule, elliptic, dorsally compressed, glabrous, pale brown, shining, somewhat woody, dehiscing loculicidally and septically, two-celled with one seed in each cell.

*Seed* large, flat, laterally compressed, suborbicular, obliquely cut away at the base on one side of the hilum, where it rests on the free apex of the retinaculum, 9 mm. long, 8 mm. wide, 1.5-2.25 mm. thick in the middle, becoming thinner towards the edges, exalbuminous; testa thin, membranous, covered with whitish, adpressed mucilaginous hairs, except a small, ovate, glabrous space on each side at the base.

*Embryo* very large, and occupying the whole of the seed, except a small portion at the obliquely cut base which is occupied with cortical matter, colourless; cotyledons large, suborbicular, deeply

notched at the base, plano-convex with a conspicuous, ramifying and forked venation, the larger lateral veins being ascending and incurved and the basal ones recurved to support the large auricles, very shortly petiolate in the seed; radicle terete, straight in the upper portion where it lies between the auricles of the cotyledons, and in the lower portion curved to that side next the base of the retinaculum, to the middle of which it is attached.

### Seedling.

*Hypocotyl* erect, terete, striate or furrowed, covered with lines of white hairs, 2-2.5 cm. above the soil.

*Cotyledons* reniform, very large, deeply and widely cordate at the base, glabrous except the petiole and base, deep green above, whitish beneath; lamina 2.5-2.9 cm. long, 4.2-4.4 cm. wide; petiole subterete or slightly flattened at the base on the upper side, hairy, 3.5-3.8 cm. long.

*Stem* erect, terete, slightly channelled, hairy; 1st internode 5-6 cm. long; 2nd 6-8 mm.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, alternately incurvinerved, hairy, crenate-serrate; petioles biconvex, or with an elevated midrib above.

First and second pairs ovate, acuminate, obtuse.

### *Strobilanthes gossypinus*, T. Anders.

*Hypocotyl* pubescent, 3-8 mm. long, reddish-green.

*Cotyledons* coriaceous, oblate or almost reniform, rather unequal, obtuse, slightly cordate at the base, entire, glabrous except on the petioles, dark green, trinerved.

*Stem* erect, terete, herbaceous, pubescent; 1st internode 3-5 mm. long; 2nd shorter.

*First leaves* opposite, decussate, shortly petiolate, ovate, subacute or obtuse, densely pubescent, dark green, alternately pinnatinerved.

### *Acanthus longifolius*, Host. (fig. 579).

*Ovary* two-celled, each cell two-ovuled; ovules alternately superposed, amphitropous; radicle transverse.

*Fruit* a capsule, ovoid-oblong, slightly contracted or narrowed at the base, and suddenly narrowed at the tip, glabrous, shining, pale brown, two-celled, with each cell one- to two-seeded, dehiscing elastically when dry along the dorsal suture and placentas from base to apex into two pieces each of which consists of half each carpel; pericarp separating into two coriaceous layers.

*Seed* large, obliquely oblong or ovate, dorso-ventrally compressed, but chiefly ventrally, smooth or variously wrinkled and ridged; testa coriaceous, deep brown; tegmen thicker, paler; hilum obliquely basal; micropyle on the opposite side from the hilum and near the middle of the seed; seed 18 mm. long, 7-10 mm. broad, 5 mm. thick.

*Endosperm* absent in the mature seed; but previous to maturity forming a layer or cup enclosing the growing embryo, close to the hilum and at the base of the seed, fleshy.

*Embryo* straight, transverse, large and ultimately occupying the whole interior of the seed; cotyledons oblate-orbicular, plano-convex, rather deeply cordate at the base with the auricles closed over the radicle, and having an oblique impression on one side near the apex caused by the attachment of the retinaculum, equal in length and breadth to the seed, closely applied face to face; radicle transverse to the seed, short, obtuse, included between the cotyledons.

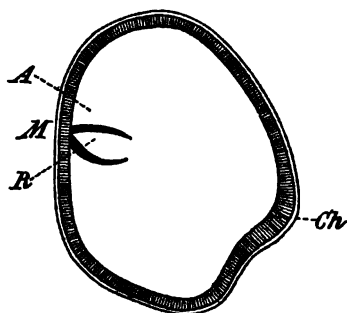


FIG. 579.—*Acanthus longifolius*,  $\times 8$ . Longitudinal section of seed: *M*, micropyle; *R*, radicle; *A*, auricle of cotyledon; *Ch*, chalaza.

### *Acanthus spinosus*, L.

*Ovary* surrounded at the base with an annular disk, two-celled; ovules attached a little above their bases to long retinacula of which there are two in each cell pointing alternately right and left; ovules oblique, amphitropous or semianatropous, with the radicle in the growing condition, at a point in a diagonal line with the insertion on the retinaculum.

*Capsule* obovoid, compressed or subcompressed, antero-posteriorly tipped with the woody remains of the base of the style, or its whole length, glabrous, deep green and shining.

*Seed* elliptic, compressed, with a slender ridge along the dorsal and ventral flattened aspects, on the latter of which it is grooved towards the base by pressure against the retinaculum, glabrous, brown; hilum obliquely basal; testa very thick and succulent when growing.

*Endosperm* in the growing seed firm, transparent, succulent and watery, occupying the lower part of the seed, stretching across the interior diagonally and abutting against the embryo, gradually

becoming less as the embryo develops, and finally disappearing when the seed approaches maturity.

*Embryo* straight in the young condition, plano-convex, colourless, fleshy; cotyledons at an early stage transversely oval, entire, gradually becoming orbicular or occasionally angled.

***Eranthemum leuconeurum*, Fisch. (fig. 580).**

*Ovary* two-celled, each cell two-ovuled; ovules erect, anatropous; radicle inferior.

*Fruit* a capsule, oblong, cuspidately acute, stipitate, dorsally compressed, pubescent with incurved hairs and tipped with the persistent style, two-celled, and four-seeded or fewer by abortion,

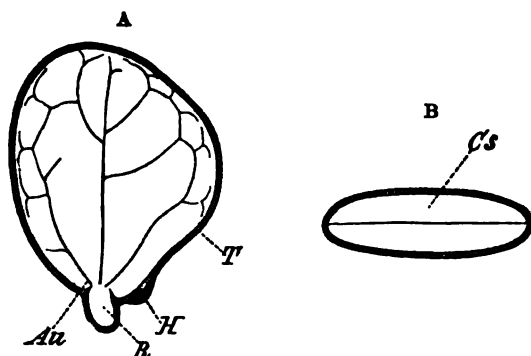


FIG. 580.—*Eranthemum leuconeurum*,  $\times 12$ . A, longitudinal section of seed: *Au*, auricle; *R*, radicle; *H*, hilar process; *T*, testa. B, transverse section of seed; *Cs*, cotyledons.

dehiscing loculicidally and elastically when mature, scattering the seeds; retinacula produced beyond the seed into subulate, acute points, and curved upwards.

*Seed* suborbicular, notched at the base, much compressed by the dorsal flattening of the capsule, lying on the retinaculum in the broader way of the cell, somewhat unequal at the base, with the point containing the radicle slightly longer and extending towards the side of the capsule; testa rather thin, reticulated or raised into irregular, wavy, projecting, slender ridges; raphe and chalaza inconspicuous; hilum and micropyle basal, inferior, contiguous but separated by a shallow notch; hilum surrounded on two sides by small auricles.

*Endosperm* in the mature seed represented by a thin white, easily separable film.

*Embryo* large, filling the seed to which it conforms, straight,

colourless; cotyledons rotund-obovate, minutely auricled at the base, otherwise entire, plano-convex, or rather flat with rounded lower edges, lying in the broader way of the seed with their backs to the placental axis and their basal edges vertical to the retinaculum; radicle very short, oblong, obtuse, much longer than the minute auricles of the cotyledons, lying in the long basal point of the seed.

**Seedling (fig. 581).**

*Primary root* long, filiform, flexuose, colourless, with slender lateral rootlets, but soon equalled or superseded by strong adventitious roots from the base of the hypocotyl.

*Hypocotyl* erect or decumbent, tapering downwards, striated longitudinally with numerous, upwardly adpressed whitish hairs, pale green, 9–15 mm. long.

*Cotyledons* obovate, shallowly emarginate, tapering to a cuneate base, petiolate, indistinctly, irregularly, alternately incurvinerved with the nerves uniting to form

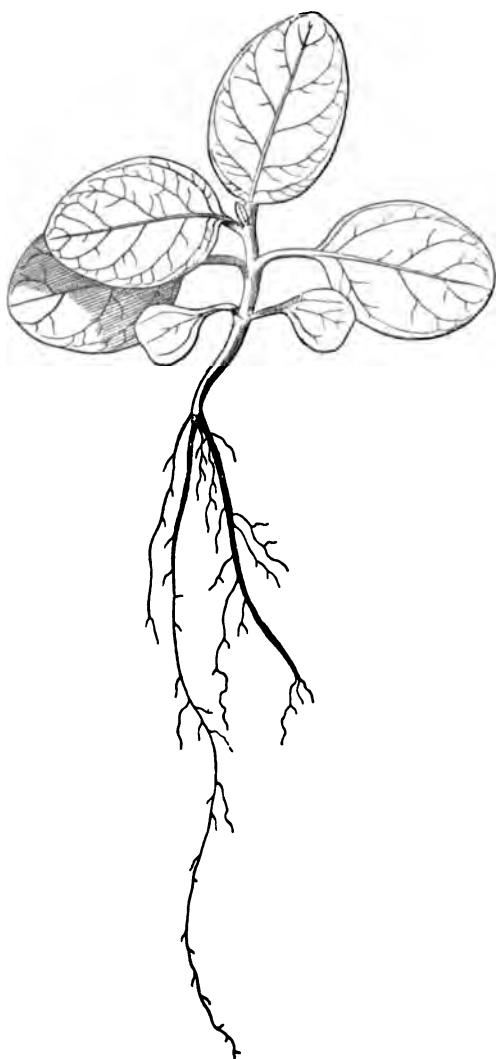


FIG. 581.—*Eranthemum leuconeurum*. Nat. size.

an irregularly outlined submarginal one, glabrous except the petiole, deep green above, pale or glaucous beneath; lamina 8–9 mm. long

and as wide; petiole flattened above or biconvex, thinly hairy, 5-6.5 mm. long.

*Stem* herbaceous, dwarf, decumbent, terete, densely hairy with adpressed hairs, pale green; 1st internode 5-6 mm. long; 2nd 5-5.5 mm.

*Leaves* simple, entire, cauline, opposite, exstipulate, petiolate, alternately incurvinerved, reticulate, ciliate, somewhat hairy beneath and on the midrib above with adpressed hairs, otherwise glabrous, deep green with irregular white bands on the principal nerves, and closely marked with minute short striæ and little gland-like dots, much paler beneath or almost glaucous; petioles biconvex, or subterete, densely covered with adpressed whitish hairs.

First pair of leaves broadly oval, rounded at both ends or slightly cordate at the base.

Second pair broadly oval, less rounded at the apex than the first pair, and slightly more cordate at the base.

***Asystasia coromandeliana*, Nees (fig. 582).**

*Hypocotyl* erect, terete, striated, glabrous, pale green, 1.8-2.2 cm. long.

*Cotyledons* obliquely or unequally rotund, entire, petiolate, suddenly tapered into the petiole, alternately incurvinerved, irregularly reticulate, glabrous, foliaceous, dull green above, pale or subglaucous beneath; lamina 2.2-2.6 cm. long, 2.3-2.5 cm. wide; petiole broadly channelled on the upper side, convex on the back, pubescent at the edges, otherwise glabrous, about 1.35 cm. long.



FIG. 582.—*Asystasia coromandeliana*.  
Half nat. size.

*Stem* erect, terete, bright green, longitudinally striate, thinly pubescent with whitish hairs curved downwards, furrowed on the sides alternating with the leaves next above; 1st internode 2.7-3 cm. long.

*Leaves* simple, entire, cauline, opposite, exstipulate, petiolate, alternately incurvinerved, and reticulate with the nerves branching,



uniting and forming a submarginal wavy line running obliquely to the margin, pubescent on the midrib above and on the principal nerves beneath, light green and shining above, subglaucous beneath ; petiole narrowly winged, semiterete, shallowly channelled above along the central ridge, pubescent with recurved hairs beneath, with a stout joint at its origin with the stem.

First pair ovate, obtuse, entire, suddenly narrowed at the base and decurrent, forming a wing to the petiole.

***Schwabea ciliaris*, Nees.**

*Hypocotyl* long, striated, minutely hairy, 8·25–9 cm. long, light green with here and there a reddish tinge.

*Cotyledons* fleshy, oblong, obtuse, emarginate, petiolate, glabrous, green, one-nerved ; petioles short, slightly hairy and slightly channelled on the upper face.

*Stem* erect, striated, hirsute, herbaceous, ultimately woody ; 1st internode 5–5·5 cm. long ; 2nd 1·5–2·5 cm.

*First leaves* simple, entire, cauline, opposite, decussate, petiolate, exstipulate, lanceolate, subacute, ciliate, slightly hairy, green, pinnatinerved ; petioles short, hairy, channelled above.

***Justicia bracteata*, Pohl.**

*Hypocotyl* erect, striated, covered with minute hairs, 3–4 cm. long, light green, tinged with red near the base.

*Cotyledons* rather fleshy, broadly obovate-oblong, slightly emarginate, shortly petiolate, glabrous, dark green, pinnatinerved like the leaves.

*Stem* erect, terete, herbaceous, minutely hairy ; 1st internode 3–5 mm. long.

*First leaves* simple, entire, cauline, opposite, ovate-oval, obtuse, ciliated, covered with minute hairs, petiolate, exstipulate, light green, pinnatinerved.

***Justicia procumbens*, Wall.**

*Hypocotyl* erect, terete, finely pubescent, 1·5–2·2 cm. long, light green or colourless.

*Cotyledons* subrotund, emarginate, obtuse, petiolate, glabrous, light green, indistinctly trinerved.

*Stem* erect, terete, pubescent ; primary internodes very short.

*First leaves* simple, entire, cauline, opposite, very shortly petiolate, exstipulate, oval, obtuse, ciliate, pubescent, pinnatinerved, light green.

***Dicliptera resupinata*, Juss.**

*Hypocotyl* erect, striated, covered with minute hairs, 8-12 mm. long, light green.

*Cotyledons* oblong, obtuse, emarginate, rather fleshy, unsymmetrical, glabrous except on the petioles, light green, trinerved.

*Stem* erect, herbaceous, striated or ribbed, covered with minute hairs; 1st internode 5-6 mm. long.

*First leaves* simple, entire, cauline, opposite, decussate, petiolate, exstipulate, ovate-oval, obtuse, covered with minute hairs, light green, pinnatinerved.

***Peristrophe speciosa*, Nees (fig. 588).**

*Primary root* tapering downwards, with numerous fibrous rootlets ultimately superseded by strong lateral rootlets.

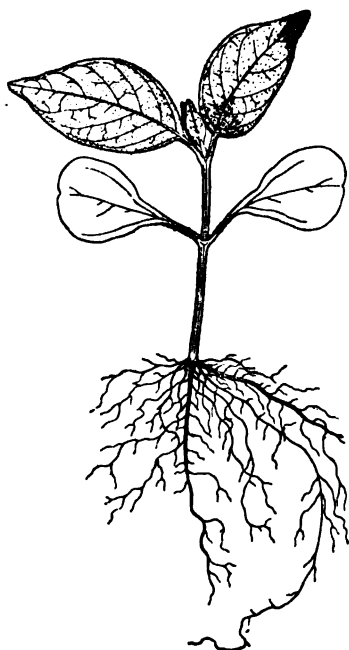


FIG. 588.—*Peristrophe speciosa*.  
Half nat. size.

*Hypocotyl* erect, terete, pubescent with short decurving hairs, pale green, 2-2.3 cm. above the soil.

*Cotyledons* large, obliquely and broadly rotund-ovate, slightly emarginate, alternately trinerved from the base with the nerves incurved and uniting with the midrib close beneath the apical notch, petiolate, glabrous except the petiole, light green above, paler beneath, suddenly tapered into the petiole; lamina 2.3-2.7 cm. long, 1.9-2.2 cm. wide; petiole semiterete, flattened above, dilated upwards into the lamina, pubescent with decurving hairs, 1-1.3 cm. long.

*Stem* herbaceous or subshrubby, erect, shallowly angled and furrowed, densely covered with short, decurving hairs; 1st internode 1.5-2 cm. long.

*Leaves* simple, entire, cauline, opposite, exstipulate, petiolate, unequal, alternately or suboppositely and incurvedly penninerved, with the nerves becoming more slender, and forming a sub-

marginal line running to the apex of the leaf, light green above, paler beneath or subglaucous, pubescent on the nerves on both surfaces, with variously curved or bent hairs; petioles semiterete, slightly channelled above, rather slender, tapering somewhat upwards, densely covered with similar hairs.

First pair elliptic-ovate, obtuse, unequal in length, suddenly tapered at the base into the petiole.

The seedling of *P. bicalyculata*, *Nees*, very closely resembles the above, but has slightly broader cotyledons.

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## SELAGINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1126.

*Fruit and Seed.*—The pistil is superior, consisting of two carpels which unite to form a two-celled ovary, or the latter by abortion becomes obliquely one-celled while the plant is yet in flower. The ovules are solitary in each cell, suspended from the apex by a shortly filiform funicle, and anatropous. The fruit is small, indehiscent, included in the calyx, and two-celled, or breaks up into two cocci, or by the abortion of one of the original carpels it consists of only one coccus. The exocarp is thin and fleshy, or crustaceous, or hardened, rarely membranous. The sides of the seed-bearing cells are sometimes furnished internally with a layer of corky matter, or two small hollows; or the fruit between the cocci is furrowed. The seed is pendulous and solitary from the apex of each coccus and is oblong or terete, with a membranous testa. A fleshy endosperm is present. The embryo is axial, straight, and terete, with the cotyledons slightly broader than the superior radicle.

The fruit of *Hebenstretia* varies in width in different species, and is also affected in this respect according as one or both carpels mature. The seed is oblong-cylindrical, conforming to the interior of the cavities, and the shape seems to determine the narrowness of the cotyledons on germination.

*Seedlings.*—A number of the *Hebenstretias* are notable for

the similarity which prevails between the cotyledons and the adult as well as the primary leaves. *H. tenuifolia* has linear cotyledons slightly broader towards the apex, tapering to a narrow base and bluntly carinate beneath with a prominent midrib. The first six leaves are in three opposite or subopposite pairs, followed by a large number of crowded alternate leaves which are linear and narrower than the cotyledons which they resemble very closely. The ultimate leaves are similar but minutely and distantly toothed at the margins. The cotyledons of *H. dentata* var. *integrifolia* are linear, rounded on the back, with a faint indication of a midrib, 1.6–1.8 cm. long and 1–1.5 mm. wide. The leaves are alternate with exception of the first pair, narrowly linear, rounded on the back like the cotyledons but longer, and entire, or the ultimate ones have a few blunt teeth near the apex.

***Hebenstretia tenuifolia*, E. Mey.**

*Primary root* tapering downwards and giving rise to numerous slender flexuose fibres.

*Hypocotyl* erect, terete, finely pubescent, soon becoming firm in texture, 2–2.8 cm. long.

*Cotyledons* linear, obtuse, entire, broadest towards the apex and tapering gradually into a narrow, petiole-like base, glabrous, slightly channelled on the upper surface, with a prominent midrib beneath or somewhat carinate, 2–2.5 cm. long, and 2–2.5 mm. wide above the middle.

*Stem* erect, terete, or bluntly quadrangular in the lower part, finely pubescent; 1st internode 7–10 mm. long; 2nd and succeeding ones very short or hardly developed.

*Leaves* simple, cauline, the lower subopposite, and the upper ones crowded and alternate, exstipulate, sessile and tapering to a narrow petiole-like base, glabrous, opaque, channelled above and obtusely carinate beneath like the cotyledons, minutely, distantly and bluntly toothed at the margins.

Nos. 1–6. In three opposite or subopposite pairs; the rest crowded, narrower than the cotyledons, and alternate.

***Hebenstretia dentata*, L., var. *integrifolia*.**

*Primary root* long, tapering, flexuose, and giving rise to numerous flexuose fibres.

*Hypocotyl* erect, terete, finely pubescent, 1·8–2·2 cm. long.

*Cotyledons* linear-obtuse, or subacute, entire, channelled above, rounded on the back with a faint indication of a midrib, glabrous, deep green, 1·6–1·8 cm. long, 1–1·5 mm. wide.

*Stem* erect, terete, finely pubescent, brownish after a time; 1st internode 1–1·2 cm. long; 2nd 4–5 mm.; succeeding ones very short.

*Leaves* simple, cauline, alternate (first two opposite), exstipulate, sessile, channelled above, tapering to a narrow petiole-like base, rounded on the back with a faint indication of a midrib similar to the cotyledons, glabrous or slightly pubescent at the base on the under side.

Nos. 1 and 2. Opposite.

Nos. 8–80. Narrow, linear, subentire or with two or three blunt teeth near the apex, alternate and crowded, similar to the cotyledons but longer.

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## VERBENACEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1181.

*Fruit and Seed.*—The ovary is superior and undivided, or four-furrowed or rarely shortly four-lobed. It consists of two carpels and normally in the young state is one-celled, with the placentas strongly intruded into the cavity, and revolute, dividing the ovary more or less perfectly into two cells, twin-ovuled, or one-ovuled by abortion. The cells afterwards become bilocellate by the development of spurious septa, and the four locelli then contain a single ovule each. In a few genera the ovary consists of four to five carpels divided into eight to ten locelli; and in the tribes Symphoremæ and Avicenniæ the ovary of the young flower is already four-celled, or one-celled at the apex only. The ovules are more or less amphitropous except in *Phryma*, *Clerodendron Kämpferi*, and possibly some others. They are inserted on the involute margins of the carpels, at the base, middle or towards the apex, with the micropyle inferior; rarely are they axial. The fruit is baccate or somewhat capsular, with a fleshy, succulent or thin and dry exocarp, and generally a hardened

endocarp. Normally, the whole fruit or the endocarp alone is indehiscent at maturity, and two- to four-celled, or the fruit breaks up into one- to two-celled lignified pieces, or four rarely eight to ten one-celled pieces. The seeds are always in separate cavities, fixed laterally to the placentas and erect, or pendulous, oblong, obovoid or subglobose. The testa is mostly membranous except in *Avicennia*. A fleshy endosperm is present in the tribes *Stilbeæ* and *Chloanthææ*, but in all other cases it is very scanty or entirely absent. The embryo is straight and equals the length of the endosperm, or fills the whole seed where endosperm is wanting. The cotyledons are flat or thickened, quite free to the base or very rarely amalgamated for great part of their length into one piece. The radicle is generally very short and always inferior except in *Phryma* which contains a single species only, the ovule and seed of which are very anomalous.

Subcentral placentas occur in *Avicennia* as well as in members of the tribes *Symphoremæ* and *Caryopteridææ*. Spurious septa are absent in the fruits of *Espadææ*. A fleshy, oily embryo with its cotyledons united to the middle occurs in *Oxera*, *Amasonia* and *Symphorema*. The embryo in *Avicennia* is naked with large plaited cotyledons.

The ovules of *Clerodendron Kæmpferi* are erect and anatropous with the micropyle inferior. The fruit breaks up at maturity into four drupe-like pieces, each containing a solitary oblong seed. The cotyledons are fleshy, plano-convex and fill the entire cavity of the seed to which they conform; they are, however, slightly auricled at the base in order to accommodate the minute, globular radicle.

*Seedlings*.—The cotyledons are all of simple types, and although five more or less distinct forms were observed, they may all be described as modifications of one another, dependent upon the size, and relative length and breadth of the seed. The simplest form is that seen in *Vitex trifolia* (fig. 585) which has small, oblong, obtuse cotyledons without apparent venation. The cotyledons of *Verbena officinalis* (fig. 584) are also small, but ovate, obtuse, with a distinct midrib and a few alternate, very faint lateral nerves. The petioles are slightly connate at the base. *Lippia juncea* in the

seedling state at least bears considerable resemblance to a *Verbena*, and has ovate-oblong cotyledons with a venation similar to that of *Verbena officinalis*. The first pair of leaves are lanceolate, followed by two pairs which are oblong. All are bluntly serrate.

A third and distinct type is that represented by *Stachytarpheta mutabilis* which has broadly and roundly ovate, mucronate, and faintly penninerved cotyledons, truncate at the base. The petioles as well as the hypocotyl are hairy. The cotyledons of *Rhaphithamnus longiflorus* do not conform very closely to the above, but are roundly ovate and one-nerved.

The cotyledons of *Callicarpa americana* are small, roundly ovate, emarginate, trinerved, pubescent and ciliate.

The fifth type is represented by *Clerodendron Kämpferi* (fig. 586) which has broadly ovate, shallowly and irregularly dentate, penninerved cotyledons, bearing some resemblance to the first pair of leaves but smaller.

***Stachytarpheta mutabilis*, Vahl.**

*Hypocotyl* erect, terete, hairy, 2·2–2·5 cm. long, light green or colourless.

*Cotyledons* broadly and roundly ovate, obtuse, entire, petiolate, truncate at the base, glabrous, green, indistinctly pinnatinerved, like the leaves; petioles flat, hairy.

*Stem* erect, terete, hairy; 1st internode 3–4 mm. long.

*First leaves* simple, cauline, opposite-decussate, exstipulate, ovate, acute, serrate, pubescent, green, alternately pinnatinerved, petiolate; petioles short, channelled, pubescent.

***Verbena officinalis*, L. (fig. 584).**

*Primary root* tapering downwards and giving off numerous lateral fibres.

*Hypocotyl* short, erect, terete, glabrous, pale green or colourless, 3–5 mm. long.

*Cotyledons* ovate, obtuse, entire, tapering into the petiole, with a distinct midrib and a few short alternate ascending nerves discernible only by transmitted light, glabrous, light green above, paler beneath; lamina 3·75–5 mm. long, 2·5–3 mm. wide; petiole flat above, convex beneath, glabrous, 2·5–4·5 mm. long.

*Stem* herbaceous, erect, terete, hairy or pubescent, pale green; 1st internode 1·5–2 mm. long; 2nd 4–6 mm.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, hairy with simple or gland-tipped hairs, alternately and ascendingly penninerved, with the nerves slightly incurved towards their apex, uniting

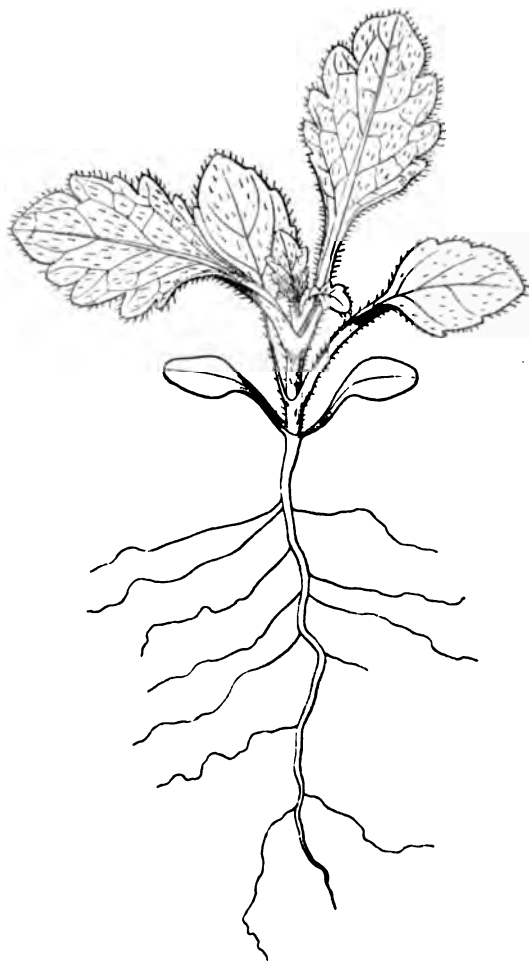


FIG. 584.—*Verbena officinalis*,  $\times 2$ .

with one another, and generally giving off branches only into the marginal serratures, bright green above, paler beneath; petioles semiterete, channelled above, hairy, with many of the hairs tipped with a gland.



First pair of leaves oval or elliptic, obtuse, or often subovate, shallowly or obsoletely serrate-dentate.

Second pair larger, more deeply serrate-dentate with obtuse teeth the terminal one of which is largest.

Third pair elliptic-oblong, obtuse, incise serrate-dentate.

***Verbena Aubletia, L.***

*Primary root* as in *V. officinalis*.

*Hypocotyl* subflexuose, pubescent, pale pinkish-white, terete, 11 mm. long, 1·25 mm. thick.

*Cotyledons* very similar to those of *V. officinalis*, 6 mm. long, 3·5 mm. wide; petiole channelled above, connate at the base, pubescent, 6 mm. long.

*Stem* herbaceous, annual, obtusely quadrangular, erect (at least the primary one), ultimately much branched, with coarse villous hairs; 1st internode 1 cm. long; 2nd 8 mm.

*Leaves* coarsely villous on both surfaces, as well as on the petioles; petioles channelled above, subconnate at the base around the stem.

First pair ovate, obtuse, subcuneate at the base, subtrifid, penninerved; lateral lobes mere teeth; terminal lobe triangular-ovate, obtuse.

Second pair triangular-ovate, obtuse, subtrinerved at the base, pinnatifid; basal lobes longest, oblong, obtuse, and entire or again cut on the posterior or basal side.

Ultimate leaves triangular-ovate, obtuse, deeply pinnatifid, subcuneate at the base, coarsely hairy on both surfaces, deep green above, paler beneath with prominent venation; lobes more or less coarsely serrate on the posterior side; basal pair distinctly the largest and sublobulate on the posterior side.

***Rhaphithamnus longiflorus, Miers.***

*Hypocotyl* erect, square, hoary, almost colourless or reddish-green, from 1–2 cm. long.

*Cotyledons* roundly ovate, coriaceous, glabrous, petiolate, entire 6–10 mm. long, 5–6 mm. wide; dark green above, whitish beneath; venation indistinct but having one primary nerve.

*Stem* herbaceous, ultimately woody, erect, square, finely pubescent, light green; 1st internode 1–1·5 cm. long; 2nd about the same.

*Leaves* simple, serrated, upper ones coarsely, lower less so and sometimes almost entire, cauline, opposite, shortly petiolate, lanceo-

late, acute, glabrous, shining green above, lighter beneath ; midrib with numerous ascending veinlets.

***Callicarpa americana*, L.**

*Hypocotyl* erect, terete, finely pubescent, 6–8 mm. long, light green or colourless.

*Cotyledons* ovate-rotund, obtuse, emarginate, petiolate, slightly hairy, green, very indistinctly trinerved ; petioles rather flat, shallowly channelled above.

*Stem* erect, terete, herbaceous, ultimately woody, thickly pubescent or hirsute ; 1st internode 6–8 mm. long ; 2nd shorter.

*First leaves* simple, cauline, opposite, decussate, exstipulate, petiolate, ovate-oblong or elliptic, obtuse, coarsely serrate, pubescent, green, lighter beneath, pinnatinerved ; petioles hairy, rather long, shallowly channelled above.

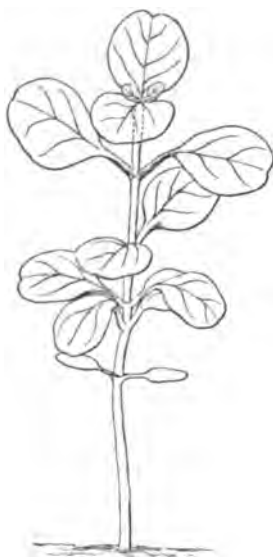


FIG. 585.  
*Vitex trifolia*. Nat. size.

***Vitex trifolia*, L. (fig. 585).**

*Hypocotyl* erect, terete, somewhat woody, pubescent, brownish, 2·2–3 cm. long.

*Cotyledons* oblong, obtuse, petiolate ; lamina 6 mm. long, 2·5 mm. wide ; petiole 8·25 mm. long.

*Stem* herbaceous or suffrutescent, erect, square, pubescent, purplish ; 1st internode 7·5 mm. long ; 2nd 2·5 mm. ; 3rd 5·5 mm. ; 4th 10 mm. ; 5th 4 mm.

*Leaves* simple, ultimately digitate, cauline, opposite, exstipulate, petiolate, covered on both surfaces with a short, dense, adpressed pubescence, and somewhat hoary ; petioles shallowly grooved

on the upper surface, grooved on the back, and pubescent like the leaves.

First to sixth pairs inclusive, simple, rotund-obovate, emarginate, otherwise quite entire, alternately penninerved.

***Clerodendron Kämpferi*, Fisch.**

*Ovary* of two carpels, four-locellate, with each cell one-ovuled ; ovule erect, anatropous ; micropyle inferior.

*Fruit* baccate, two- to four-angled or -lobed when mature, glabrous, two- to four-celled, with a seed in each cavity that develops and comes to maturity, and falling away into as many nuts or drupes as there are locelli.

*Seed* ascending or erect from the base of the inner angle of the cell, somewhat compressed dorso-ventrally, and slightly curved longitudinally, and more or less wrinkled in that direction when dry, glabrous, whitish, exalbuminous; testa thin, membranous; hilum and micropyle basal, contiguous; funicle short, broad, and thin; chalaza apical, superior.

*Embryo* comparatively large, filling the entire seed and conform-

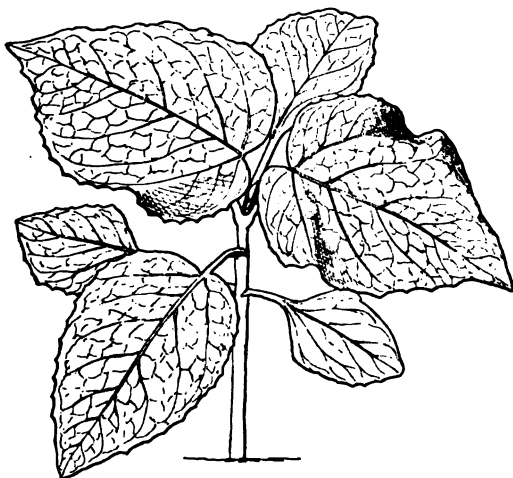


FIG. 586.—*Clerodendron Kampferi*. Nat. size.

ing to it in outline, slightly curved accordingly, colourless; cotyledons oblong, obtuse, entire, or very shallowly auricled at the base, lying in the broader plane of the seed with their backs to the axis of the fruit, thick, fleshy, plano-convex; radicle very minute, globose, obtuse, lying in the very base of the seed and projecting only slightly beyond the cotyledons.

#### **Seedling (fig. 586).**

*Hypocotyl* rather succulent, terete, 2 cm. long, 2.5 mm. thick, pubescent, bright green.

*Cotyledons* stalked, about 8 cm. long, 1.5 cm. wide, ovate, oblique at the base, obtuse, shallowly irregularly dentate towards the apex;

lower part entire, pubescent all over (as is the case with the whole plant above ground), rather thin, penninerved and reticulate, of a dark metallic green above, slightly paler beneath.

*Stem* with short internodes, herbaceous, terete, pubescent.

*Leaves* simple, cauline, opposite, decussate, exstipulate, petiolate, thin, dentate, alternately penninerved; nerves incurving, reticulate, pubescent all over.

First pair like the cotyledons only larger, and showing transition to the cordate form.

Second pair cordate, acute, wavy at the margin, dentate.

Third pair cordate, equal and regular, acute, finely dentate, alternately penninerved, reticulate.

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## LABIATÆ.

Benth. et Hook. *Gen. Pl.* ii. 1160.

*Fruit and Seed.*—The ovary is superior, syncarpous and four-partite to the base, more rarely shortly four-fid or -lobed beyond the middle. It consists of two carpels with their marginal and dorsal sutures so inflected as to form two pairs of one-celled cavities. The style is central and gynobasic. The ovules are solitary in each cell, and with few exceptions erect and anatropous. The fruit is most often included in the persistent calyx and consists of four lobes or nutlets or fewer by abortion; and each nutlet encloses a single seed and is indehiscent. The nutlets are dry, crustaceous or hard, rarely fleshy or drupaceous, smooth, tuberculate, or roughly reticulate, rarely surrounded with a wing-like appendage, and attached near the base by a small oblique or lateral areola to that part of the ovary bearing the style. The seed conforms to the interior of the nutlet and is attached by the very base or laterally near the base to the placenta, and is rarely incurved the testa is membranous. Endosperm is scanty or altogether wanting. The embryo again conforms to the seed and has flat or plano-convex, slightly fleshy cotyledons parallel or rarely transverse to the axis of the fruit. The radicle is short, inferior and straight, or rarely incurved with incumbent or recumbent cotyledons.

The ovary is usually stipitate in *Scutellaria* as is the shortly lobed ovary in the tribes *Prostantheræ* and *Ajugoidæ*.

The nutlet is depresso-globose in *Salazaria* and *Scutellaria*, fleshy in *Gomphostemma* and subdrupaceous in other members of the tribe *Prasiæ*. The radicle is long and incurved in *Catopheria*, with accumbent cotyledons. The seed is transverse to the axis in *Salazaria* and *Scutellaria* with an incurved radicle and incumbent cotyledons.

About five more or less distinct types of seeds have come under my notice differing chiefly in shape, dependent upon that of the nutlet containing them. One of the simplest forms is that represented by *Salvia Sclarea* (fig. 589) which has small obovoid seeds with a straight embryo conforming to the interior. The cotyledons are oval, plano-convex, and slightly auricled at the base to accommodate the radicle. There is a thin film of endosperm in the seed, but so small as to be practically of no importance. The seed of *Thymus Mastichina* differs in being very much smaller and globose with suborbicular cotyledons.

A second type is that shown by *Salvia argentea*. The nutlet and seed are broadly oblong-oval. The cotyledons are similar in outline, plano-convex and rather deeply auricled at the base. The transverse section of the nutlet, seed and embryo is elliptic, or slightly trigonous. *Teucrium multiflorum* conforms pretty closely to this type, but the nutlets are muricate or covered with little tubercles.

*Salvia verbenacoides* has a smooth nutlet, broadly oval in transverse section, but otherwise conforming to *S. argentea*.

The nutlet of *Ocimum Basilicum* is oblong-ovate with rather a notable constriction about the middle. The cotyledons conform to this outline and are shortly auricled at the base. In transverse section the nutlets are broadly oval.

The nutlets of *Nepeta nuda* (fig. 593) are notably trigonous in transverse section, broadly oblong-oval in outline, and scabrid or muricate all over the surface. The cotyledons in conforming to this characteristic shape are of different forms or differently disposed while yet in the seed. That on the ventral aspect is convexo-concave, with a blunt angle next

the axis of the fruit, while the other is biconvex and fits into the bend of its fellow. Both are very deeply auricled at the base and fold over the back of the radicle nearly concealing all but the tip. The nutlets of *Lallemantia peltata* are obovoid and smooth, but the transverse section is similar to that of the last, and the cotyledons are broadly obovate, shallowly auricled, and similarly disposed to those of *Nepeta nuda* in order to conform to the shape of the seed. The nutlets, the seed and the very short stout radicle of *Prunella grandiflora* resemble those of *Lallemantia peltata*.

The nutlet and seed of the species of *Scutellaria* noticed differ from all others in the Order. The nutlet of *S. gale-riculata* is oval in outline, dorsally compressed with a ridge on the ventral face to accommodate the radicle, and rugose or tuberculated all over the surface. The ovule and seed are campylotropous. The cotyledons are oval in outline, plano-convex, entire, and incumbent. The radicle is folded along the ventral aspect of the seed, and is about half the length of the cotyledons. *S. altissima* closely conforms to the above in every respect, except that the radicle is slightly longer or about two-thirds the length of the seed. The hilum is therefore above the middle of the seed on the ventral aspect. *S. peregrina* is closely similar to the above, but the radicle is three-fourths as long as the cotyledons and seed, and is accommodated in a ridge on the ventral face of the latter. The absence of the auricles at the base of the cotyledons seems to be peculiar to this genus, and is brought about by the folding of the radicle on the ventral face of the seed, instead of this being straight and situated between the bases of the two cotyledons.

*Seedlings*.—The cotyledons are all of simple types. They vary slightly in form according to that of the seed from which they spring, but often undergo considerable modification after germination. Many, though by no means all, of those observed may be reduced to three types. One of the more common is that represented by *Salvia Columbariæ* (fig. 590) which has triangular, obtuse, emarginate cotyledons rather deeply auricled at the base. This form is due to that of the seed, which the embryo wholly occupied as ex-

plained above. The basal auricles of the cotyledons although always present in the seed often become nearly obliterated by growth after germination when they spread out, making the base of the lamina more or less perfectly truncate. This is nearly the case in *S. triangularis* which has indistinctly penninerved cotyledons, but otherwise conforms to the type.

The cotyledons of *Nepeta tuberosa* vary slightly between triangular and orbicular and are emarginate. The cotyledons of *Salvia hispanica* are relatively broader, trinerved and finely pubescent. Those of *Nepeta nuda* (fig. 594) and *Salvia argentea* differ in being somewhat more rounded at the apex, and more deeply cordate at the base. Those of the former are notable for a cavity or depression at the base of the lamina caused by the radicle and plumule while yet in the seed.

A second type having reniform emarginate cotyledons occurs in *Nepeta Glechoma*. The cotyledons of *Ocimum Basilicum* and *Perilla nankinensis* (fig. 587) are more or less perfectly truncate at the base and emarginate. The basal auricles present in the seed get obliterated by spreading out after germination. A slight modification of this type occurs in *Salvia clandestina* which has trinerved entire cotyledons, truncate at the base. A third type is represented by *Dracocephalum peltatum* (fig. 592) which has suborbicular emarginate cotyledons distinctly auricled at the base.

*Elsholtzia cristata*, *Lallemantia iberica*, and *L. canescens* agree pretty closely with this type, as also does *Monardella Pringlei*. The small size of the cotyledons and the length of the petioles of the first pair of leaves, as compared with those that follow, are noteworthy. The cotyledons of *Eremostachys laciniata* are faintly trinerved and differ from the type chiefly in being more elongated and roundly oblong.

*Acanthomintha ilicifolia* (fig. 588) constitutes a fourth type having small orbicular cotyledons, auricled at the base but otherwise entire.

The cotyledons of *Salvia verbenacoides* (fig. 591) differ slightly from those of the above in being subtruncate at the

base. Those of *Satureia hortensis* differ only in having slightly wider basal auricles. The first pair of leaves are broadly oval and entire.

The ovate-oblong cotyledons of *Teucrium Botrys* (fig. 595) represent a very unusual form and, as far as I am aware, occur only in the tribe Ajugoideæ. The leaves are glandular-pubescent and cuneate at the base, and show an interesting evolution somewhat on a ternary plan. The first pair are simply crenate; the second pair lobulate; while the third and fourth pairs are deeply trifid and tripartite respectively with the lobes cuneate and more or less distinctly trifid. The cotyledons of *Ajuga Chamæpitys* (fig. 596) are much smaller and oblong, but otherwise conform to those of *Teucrium Botrys*. The first pair of leaves are oblong or spatulate and entire; the second pair lanceolate with a tooth on each side; the third and fourth cuneate and trifid at the ends, while the fifth and sixth pairs are pinnatifid.

The cotyledons of *Galeopsis pyrenaica* are obovate or oblong-obovate, emarginate, with small ovate or triangular auricles, and thus differ from any of the above types.

Those of *G. Ladanum* are also unique in being sub-orbicular, emarginate with a sudden contraction a little above the base of the lamina. The first pair of leaves are broadly ovate and crenate; while the next two pairs are oblong-ovate. All are penninerved.

#### ***Ocimum Basilicum*, L.**

*Hypocotyl* erect, terete, minutely pubescent, 1-2 cm. long, with a reddish tinge.

*Cotyledons* fleshy, unequal, triangular or reniform, emarginate, slightly cordate at the base, petiolate, light green, glabrous except on the petiole; midrib apparent only at the base.

*Stem* short, erect, herbaceous; primary internodes but slightly developed.

*First leaves* simple, cauline, opposite, slightly toothed, ovate-lanceolate, acute, sessile, glabrous, pale green, pinnatinerved.

#### ***Elsholtzia cristata*, Willd.**

*Hypocotyl* erect, terete, finely pubescent, 9-12 mm. long, almost colourless or stained with red.



*Cotyledons* oblong-rotund, obtuse, emarginate, slightly auricled at the base, subfleshy, petiolate, glabrous, green, without any apparent venation; petioles hairy, short, shallowly channelled on the upper side.

*Stem* erect, square, pubescent; 1st internode 3-5 mm. long.

*First leaves* simple, cauline, opposite, decussate, shortly petiolate, exstipulate, ovate, obtuse, crenate-serrate, covered with hairs, green, pinnatinerved.

*Perilla nankinensis*, Decne. (fig. 587).

*Primary root* vertical, slender, grey, with a few lateral fibres.

*Hypocotyl* 2-3 cm. long, 1 mm. thick, terete, pubescent, colourless.

*Cotyledons* including petiole 1 cm. long, 1 cm. wide, unequal, shortly stalked, subreniform, obtuse, emarginate, otherwise entire, obscurely nerved, pubescent, dark green above, purplish beneath, flat, not very thick or persistent.

*Stem* erect, obtusely angular, substriate, thinly pubescent, deep purplish-red; hairs deflexed or hooked backwards; 1st internode 3.3-4 cm. long, rather variable in length; 2nd 4-6 mm.

*Leaves* cauline, opposite, simple, exstipulate, petiolate, sparsely hairy on both surfaces and pubescent on the midrib; hairs thickened at the base, hyaline above and tipped with violet.

First pair rotund-ovate or elliptic, obtuse, obsoletely serrate-crenate, penninerved, a deep black purple; petiole flattened above, convex beneath, pubescent on both surfaces.

Second pair broadly rotund-ovate, obtuse, crenate-serrate, penninerved, similar to the first pair except in the larger size and greater breadth at the base.

*Monardella Pringlei*, A. Gray.

*Hypocotyl* short, erect, terete, minutely pubescent, 2-3 mm. long, reddish-green.

*Cotyledons* small, subrotund, emarginate, cordate at the base, petiolate, glabrous except on the petioles, fleshy green, without any apparent venation.

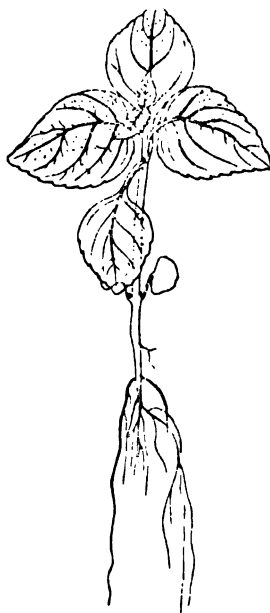


FIG. 587.—*Perilla nankinensis*.  
Half nat. size.

*Stem* erect, square, minutely pubescent; 1st internode about 1.5 cm. long; 2nd 1-1.2 cm.

*First leaves* simple, entire or minutely crenate, cauline, opposite, decussate, petiolate, exstipulate, lanceolate-oblong, obtuse, minutely pubescent, green, distinctly and alternately pinnatinerved; petioles of the first pair very long; 2nd and 3rd considerably shorter.

***Satureia hortensis*, L.**

*Hypocotyl* erect, terete, 6-10 mm. long, reddish-brown, minutely pubescent.

*Cotyledons* subrotund, obtuse, entire, auricled at the base, petiolate, glabrous, green, indistinctly one-nerved; petioles rather long, hairy, slightly channelled on the upper side.

*Stem* erect, square, finely pubescent; 1st internode 2-3 mm. long.

*First leaves* simple, entire, cauline, opposite, decussate, petiolate, exstipulate, broadly oval, obtuse, minutely pubescent, green, pinnatinerved.

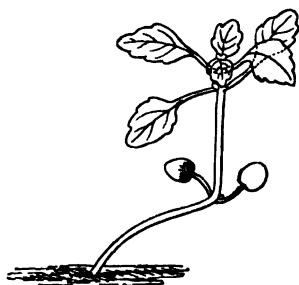


FIG. 588.  
*Acanthomintha ilicifolia*.  
Nat. size.

***Acanthomintha ilicifolia*, Wright**  
(fig. 588).

*Primary root* annual, fibrous.

*Hypocotyl* slender, wiry, terete, pubescent, purple, frequently bent or twisted, 1.8 cm. long or shorter.

*Cotyledons* rather fleshy, rotund, subcordate at the base, entire or slightly emarginate at the apex, glabrous; petiole pubescent, flattened

above, 4-5 mm. long.

*Stem* erect, obtusely quadrangular, pubescent, purple; 1st internode 1.8 cm. long; 2nd 2 mm.; stem leafy, branched from the base.

*Leaves* simple, cauline, opposite, decussate, petiolate, exstipulate, pubescent, ultimately glabrous; petioles subterete, flattened above or channelled, pubescent.

First pair ovate-oblong, obtuse, crenate-serrate, with ascending nerves.

Second pair ovate, obtuse, obtusely serrate, cuneate at the base, with ascending nerves.

Third pair ovate, obtuse, more deeply serrate than the second pair.

Ultimate leaves rotund or ovate-cuneate, narrowed to a short petiole, alternately and ascendingly penninerved, coarsely and bluntly toothed.

*Bracts* opposite, orbicular, often larger than the leaves, finely reticulate with long, spinous, diverging teeth.

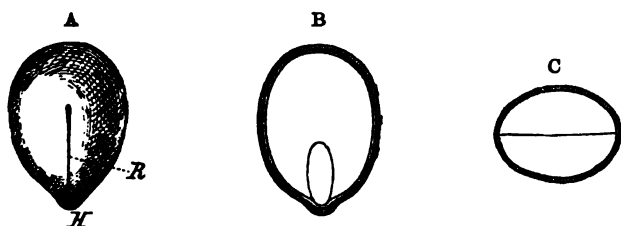


FIG. 589.—*Salvia Sclarea*. A, ventral aspect of seed,  $\times 8$ : H, hilum; R, raphe. B, longitudinal section of seed,  $\times 8$ . C, transverse section of seed,  $\times 8$ .

***Salvia Sclarea*, L. (fig. 589).**

*Fruit* separating into four nutlets (or fewer by abortion), each consisting of an outer soft integument and an inner thick and leathery one, and containing one seed.

*Seed* obovoid, pale brown, very finely reticulate; testa thin, membranous; hilum basal and slightly oblique; raphe ventral or on the same side to which the hilum is directed, passing along to a point above the middle of the seed; chalaza small, punctiform, above the middle of the seed.

*Endosperm* forming an extremely thin layer surrounding the embryo, and adhering to the testa.

*Embryo* straight, large, colourless, filling the interior of the seed and conforming to it; cotyledons plano-convex, following the outline of the seed and accordingly broadly orbicular or oval in longitudinal section, entire at the apex, slightly notched at the base; radicle very short, stout, almost included between the cotyledons.

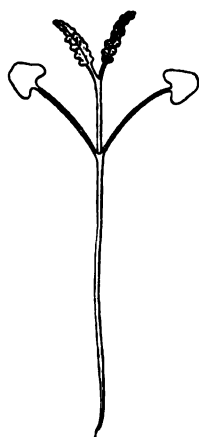


FIG. 590.  
*Salvia Columbaria*.  
Nat. size.

***Salvia Columbaria*, Benth. (fig. 590).**

*Primary root* small, eventually throwing off a few lateral fibres.

*Hypocotyl* 2–3 cm. long, .75 mm. thick, terete, glabrous, colourless.

*Cotyledons*.—Lamina 8–4 mm. long, 4–5 mm. wide, triangular, emarginate, cordate at the base, pubescent, very obscurely nerved, not very persistent; petiole slender, 1–1·5 cm. long, .5 mm. thick, finely pubescent.

*Stem* succulent, slightly pubescent, rounded, light green; internodes about 1 cm. long, .75 mm. thick, or altogether undeveloped in the open ground in the seedling stage.

*Leaves* radical and cauline, simple, opposite, decussate, exstipulate, petiolate, rugose, pubescent or subscabrous from short white hairs; petioles channelled above, convex beneath, pubescent.

First pair linear-oblong, obtuse, pinnatifid; lobes shallow, roundish-triangular.

Second pair oblong, obtuse, pinnatifid with shortly oblong, obtuse lobes.

***Salvia triangularis*, Thunbg.**

*Primary root* tapering downwards with several long, strong lateral rootlets.

*Hypocotyl* erect, terete, pubescent, 4–6 mm. long, light green or colourless.

*Cotyledons* very similar to those of *S. Columbariæ*, but glabrous and indistinctly pinnatinerved, like the leaves in their venation; petioles 5–6 mm. long.

*Stem* short, erect, herbaceous, pubescent, primary internodes but slightly developed.

*First leaves* ovate, obtuse, ciliated, simple, crenate, petiolate, thickly pubescent, light green, distinctly pinnatinerved.

***Salvia hispanica*, L.**

*Hypocotyl* as in *S. triangularis*, 8–12 mm. long.

*Cotyledons* widely triangular, emarginate, cordate at the base, shortly petiolate, minutely pubescent, light green, indistinctly trinerved.

*Stem* erect, minutely pubescent.

***Salvia argentea*, L.**

*Fruit* consisting of four dorsally compressed, almost triangular nutlets.

*Seed* conforming in shape to the nutlet, exalbuminous, 2·5–3 mm. long; testa smooth, membranous; hilum inconspicuous.

*Embryo* straight, filling the whole of the seed, colourless; cotyledons broadly oblong, plano-convex, obtuse, about the same width

throughout, with rather large auricles, otherwise entire, lying the broad way of the seed, with their faces to the axis; radicle short, terete, obtuse, lying close to the hilum.

### Seedling.

*Primary root* stout, tapering, giving off lateral adventitious rootlets.

*Hypocotyl* terete, stout, fleshy, wrinkled transversely, 6–9 mm. long, 1.5–2 mm. thick.

*Cotyledons* rotund, obtuse, auricled at the base, rather fleshy, glabrous, 1 cm. long, 1.3 cm. wide; petiole subterete, channelled above, coarsely pubescent, 1.2 cm. long.

*Stem* undeveloped in the early stage of the plant.

*Leaves* simple, radical, petiolate, rugose, woolly on both surfaces with long white hairs, especially when young.

First pair oblanceolate, obtuse, obtusely serrate, gradually tapering at the base into a short petiole, nerves ascending.

Second pair ovate-oblong, obtuse, crenate-serrate, with ascending and much anastomosing veins.

### *Salvia clandestina*, L.

*Hypocotyl* short, erect, finely pubescent, 4–5 mm. long, light green or colourless.

*Cotyledons* oblate or subreniform, entire, obtuse, with long petioles, glabrous, dark green, trinerved.

*Stem* short, erect, herbaceous, quadrangular; 1st internode 2–2.5 mm. long; 2nd shorter and so near the first that the second pair of leaves appear as though they formed a whorl of four with the first pair.

*Leaves* cauline, ovate or oval, obtuse or subacute, crenate, somewhat wrinkled, pubescent, with amplexicaul petioles, dark green; midrib with numerous ascending veinlets.

### *Salvia verbenacoides*, Brot. (fig. 591).

*Primary root* long, stout, fleshy, tapering, colourless, with a few lateral rootlets, especially near the top.

*Hypocotyl* very short, stout, fleshy, subterranean, colourless, 4.5 mm. long.

*Cotyledons* roundly triangular, subtruncate or slightly notched at the base, fleshy, petiolate; lamina glabrous, 5 mm. long, 6 mm. wide; petiole hairy, convex on upper and under sides, 8 mm. long.

*Stem* herbaceous, elongated when about to flower.

*Leaves* simple, radical, cauline, rugose, deep green above, paler beneath, finely pubescent or scaberulous on both surfaces, coarsely hairy on the midrib when young, ultimately losing these hairs; petioles channelled above, dilated and clasping at the base, convex beneath, coarsely hairy, purplish.



FIG. 591.—*Salvia verbenacoides*.  
Half nat. size.

First pair ovate, obtuse, cuneate at the base, crenate.

Second pair ovate-oblong, obtuse, cuneate at the base, crenate.

Third pair oblong, obtuse, cuneate at the base, rather coarsely crenate.

Fourth pair developing unequally and appearing alternate, oblong, obtuse, doubly crenate.

Ultimate radical leaves oblong, obtuse, obtusely lobulate, crenate, unequal at the base,

reticulate; petiole long, shallowly channelled with a thickened margin. Cauline leaves similar, gradually shorter with shorter petioles.

***Dracocephalum peltatum*, L. (fig. 592).**

*Primary root* long, flexuose, with numerous lateral rootlets. Rootstock perennial.

*Hypocotyl* short, stout, merging into the root.

*Cotyledons* foliaceous, glabrous, petiolate; lamina oblong-reniform, 9 mm. long, 8 mm. wide; petiole semiterete, flattened above, finely pubescent, 12 mm. long.

*Stem* herbaceous, elongated when about to flower.

*Leaves* simple, radical (and ultimately cauline), opposite, exstipulate, petiolate, dentate-serrate, finely pubescent on both sides; petioles channelled on the upper side, dilated at the base, pubescent.

First pair small, ovate, obtuse, cordate at the base.

Second pair rotund-cordate, obtuse.

Third pair cordate, obtuse.

Fourth pair oblong, obtuse, cordate at the base.

Ultimate leaves cordate, obtuse, obtusely dentate-serrate, five-nerved at the base and deeply cordate.

***Nepeta nuda*, L. (fig. 598).**

*Fruit* of four nutlets, separating when mature, oblong-oval, convex and flattened dorsally, obtusely angled on the ventral

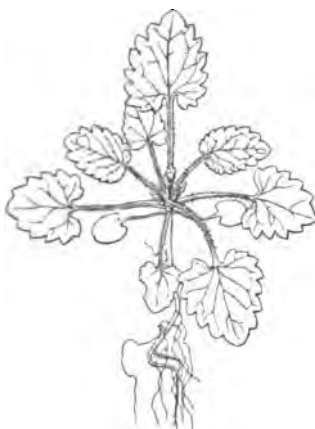


FIG. 592.—*Dracocephalum peltatum*.  
Half nat. size.

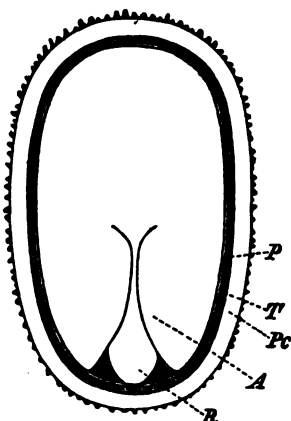


FIG. 598.—*Nepeta nuda*,  $\times 25$ . Longitudinal section of nutlet: *R*, radicle; *A*, auricle of cotyledon; *Pc*, pericarp; *T*, testa; *P*, endosperm.

aspect, scabrid, black, with a white, transverse scar a little above the base on the ventral aspect; pericarp separable into an outer rather soft dark layer, and an inner paler leathery one.

*Seed* conforming to the shape of the nutlet, and filling it entirely if properly developed, pale grey; hilum nearly or quite basal; micropyle contiguous, basal; raphe ventral; chalaza some distance below the apex on the ventral aspect.

*Endosperm* forming a thin film lining the interior of the testa, white.

*Embryo* straight, filling the entire seed with the exception of the film of endosperm, colourless; cotyledons oblong-oval, rounded at the apex, auricled at the base, one concavo-convex, the other biconvex, as long as the cavity of the seed; auricles produced along the sides and partly over the back of the radicle to fill up the space in the seed; radicle oblong, obtusely pointed, protruded only a little way beyond the cotyledons.

**Seedling (fig. 594).**

*Primary root* slender, tapering, normal.

*Hypocotyl* erect, terete, densely glandular-pubescent, 3–4 mm. above the soil.

*Cotyledons* rotund-cordate, obtuse, entire, rather deeply auricled at the base, petiolate, rather densely glandular-pubescent on both surfaces, dull opaque green or slightly hoary with a few alternate incurved nerves seen with difficulty even by transmitted light; lamina 3.5–5 mm. long, 2.5–5 mm. wide; petiole semiterete, grooved above, densely glandular-pubescent, pale green, 4.5–6.5 mm. long.



FIG. 594.—*Nepeta nuda*,  $\times 2$ .

*Stem* herbaceous, erect, densely glandular-pubescent, obtusely quadrangular; 1st internode 1 mm. long.

*Leaves* simple, cauline, opposite, exstipulate, petiolate, alternately, ascendingly incurvinerved, densely glandular-pubescent on both surfaces, dull green or somewhat hoary; petiole semiterete, channelled above, densely glandular-pubescent, pale green.

First pair rotund-obtuse, unequally crenate suddenly narrowed into the petiole, almost truncate, few-nerved.

### ***Nepeta Glechoma*, Benth.**

*Hypocotyl* succulent, pubescent, pale green, about 4 mm. above ground.

*Cotyledons* reniform, emarginate, pale green, somewhat fleshy, pubescent, 5.25 mm. long, 6.75 mm. wide; petiole 5 mm. long.

*Stem* herbaceous, erect, ultimately procumbent, throwing out prostrate branches from the axils of the cotyledons, square, pubescent with a few coarse interpetiolar hairs at the nodes; 1st internode 1 mm. long; 2nd 1.5 mm.; 3rd 2 mm. Flowering stems short, erect.

*Leaves* densely pubescent on both surfaces and thinly covered with coarse jointed hairs, deep green above, paler beneath; petioles channelled above, pale green, densely pubescent with short decurved hairs intermixed with a few scattered long ones.

First pair reniform, crenate, seven-toothed.

Second pair rotund-cordate, crenate, nine-toothed, five-nerved at the base with a few alternate ascending nerves on the upper half.

Ultimate leaves reniform or broadly cordate with a deep basal sinus, and rounded more or less open or overlapping auricles, crenate,



five-nerved, reticulate, rugose, deep green and scabrously hairy above, paler beneath, punctate and hairy on the nerves.

***Nepeta tuberosa*, L.**

*Hypocotyl* 8–16 mm. long, about 1 mm. thick, soft and herbaceous, densely pubescent.

*Cotyledons* petiolate, triangular or rotund, emarginate, truncate at the base or subauricled, pale green, densely pubescent and subglandular on both surfaces, as is the terete petiole.

*Stem* erect, herbaceous, pale green or suffused with red, obtusely quadrangular, densely pubescent and subglandular; internodes variable in length according to cultivation.

*Leaves* cauline.

First pair rotund-cordate, obtuse, subcrenate, penninerved, rugose, densely pubescent on both surfaces and subglandular, herbaceous and soft in texture; petiole terete, channelled above, densely pubescent and subglandular.

Second pair more deeply cordate at the base, and more deeply crenate.

***Lallemantia peltata*, Fisch. et Mey.**

*Fruit* consisting of four dorsally compressed, triangular nutlets.

*Seed* conforming to the shape of the nutlet, flattened, about 1–1.5 mm. long, exalbuminous; testa membranous; hilum inconspicuous.

*Embryo* straight, colourless, filling the seed; cotyledons broadly oblong or obovate, obtuse, entire, rather unequal, lying face to face; one concavo-convex, the other biconvex, lying the broad way of the seed; radicle short, terete, obtuse.

***Lallemantia canescens*, Fisch. et Mey.**

*Hypocotyl* erect, terete, glabrous, 1.2–1.6 cm. long, light green or colourless.

*Cotyledons* suborbicular, auricled or cordate at the base, emarginate, glabrous, pinnatinerved as in the leaves; petioles long.

*Stem* erect, square, glabrous; 1st internode 5–6 mm. long; 2nd shorter.

*First leaves* simple, opposite, one growing faster than another, ovate-oblong, obtuse, crenate, exstipulate, glabrous, green, pinnatinerved; petioles long.

***Lallemantia iberica*, Fisch. et Mey.**

*Hypocotyl* minutely pubescent, 3-4.5 cm. long.

*Cotyledons* very like the last species, reniform-orbicular, deeply auricled at the base, glabrous except on the petioles.

*Stem*.—Primary internodes undeveloped.

*First leaves* ovate-lanceolate, acute, slightly toothed, minutely pubescent, pinnatinerved.

***Galeopsis pyrenaica*, Bartl.**

*Primary root* an abruptly tapering taproot, giving off numerous fibrous lateral rootlets.

*Hypocotyl* erect, terete, glabrous, pale green, becoming stronger upwards, 3-6 cm. long.

*Cotyledons* broadly oblong or oblong-obovate, or obovate, petiolate, emarginate, auricled at the base with two small ovate or triangular obtuse or subacute auricles, very indistinctly trinerved with the nerves running from the base and becoming incurved to the apex; lamina glabrous, 1-1.5 cm. long, .8-1.2 cm. wide; petiole slightly connate at the base, semiterete, channelled above, ciliate at the margins .9-1.5 cm. long.

The shape of the cotyledons is very unusual for this Order.

*Stem* herbaceous, erect, obtusely quadrangular, hairy, with many of the hairs glandular, especially the shorter ones; 1st internode .8-3 cm. long.

*Leaves* simple, cauline, opposite, exstipulate, hairy on both surfaces and thinly glandular, petiolate, penninerved, with ascending nerves running into the sinus, not into the teeth; petiole semiterete, channelled above and hairy.

*First pair* broadly oblong, obtuse, minutely emarginate, bluntly and rather distantly serrated.

***Galeopsis Ladanum*, L.**

*Hypocotyl* covered with minute hairs, reddish, 1-1.5 cm. long.

*Cotyledon* rotund, ovate-obtuse, emarginate, petiolate, glabrous except on the petiole, green, indistinctly one-nerved, constricted a little above the base.

*Stem* erect, square, herbaceous, pubescent, annual; 1st internode 2-2.5 cm. long; 2nd 4-5 mm.

*First leaves* simple, cauline, opposite, exstipulate, petiolate, varying from ovate to lanceolate, obtuse, obtusely serrate, pubescent, light green, pinnatinerved; petioles short, pubescent, channelled on the upper face.

**Eremostachys laciniata**, *Bung.*, var. *pinnatisecta*.

*Hypocotyl* erect, terete, glabrous, 2-4 mm. long, light green or colourless.

*Cotyledons* thick, fleshy, unequal, broadly oblong, emarginate, obtuse, auricled at the base, petiolate, glabrous, indistinctly trinerved, green. The emargination is due to after-growth, for the cotyledons are entire at first.

Primary internodes of the stem undeveloped.

*First leaves* radical, ovate, obtusely crenate, covered with hairs, light green, pinnatinerved; petiole long, hairy, channelled on the upper side.

**Teucrium Botrys**, *L.* (fig. 595).

*Primary root* tapering, long, slender, colourless, with short lateral fibres, annual.

*Hypocotyl* subterranean, terete, glandular-pubescent, tapering gradually into the root.

*Cotyledons* rather fleshy, glandular-pubescent, petiolate; lamina ovate-oblong, obtuse, submucronate, 5 mm. long, 4 mm. wide.

*Stem* annual, short and erect at first with very shortly developed internodes, ultimately long and procumbent.

*Leaves* simple, radical and cauline, opposite, decussate, exstipulate, petiolate, opaque green, densely glandular-pubescent on all parts; petioles channelled above, convex beneath, somewhat dilated at the base; nerves of leaf all sunk.

First pair triangular, obtuse, nearly truncate at the base, rather deeply crenate.

Second pair triangular, obtuse, lobulate; lobes entire, or basal ones with a tooth on the posterior side.

Third pair triangular, pinnatifid; basal lobes unequally bifid or trifid; next pair of lobes tridentate.

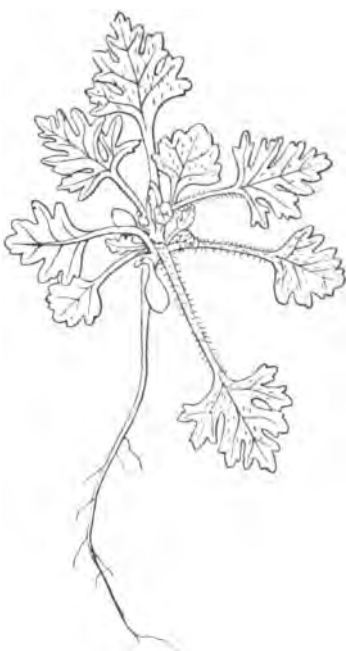


FIG. 595.—*Teucrium Botrys*.  
Nat. size.

Fourth pair triangular and similar to the last, but the segments are more slender and more numerous.

**Ajuga Chamæpitys, Schreb. (fig. 596).**

*Primary root* tapering, flexuose, giving off lateral, fleshy, much branched secondary roots.

*Hypocotyl* ascending, terete, fleshy, glabrous, reddish, 8 mm. long.

*Cotyledons* oblong, obtuse, glabrous, petiolate; lamina 4 mm. long, 1.5 mm. wide; petiole 2 mm. long.



FIG. 596.—*Ajuga Chamæpitys*.  
Nat. size.

*Stem* herbaceous decumbent, branching.

*Leaves* simple, radical and cauline, opposite, exstipulate, petiolate, gradually decurrent on the petiole almost or quite to the base except in the primary leaves, deep green above, glaucous beneath and strongly ribbed, revolute at the margins.

First pair small, oblong, obtuse or sub-acute, entire, distinctly petiolate; lamina 4.5 mm. long, 2.25 mm. wide.

Second pair lanceolate, obtuse, tapering somewhat to both ends with generally a small tooth on each side.

Third pair similar to the second but larger, with a deeper blunt tooth on each side, trinerved.

Fourth pair narrowly cuneate, deeply trifid, with oblong, obtuse lobes, trinerved.

Fifth pair rather unequal, one leaf pinnatifid with four oblong, obtuse lobes and a larger terminal one; the other leaf deeply trifid.

Sixth pair narrowly oblong, pinnatifid, with linear-oblong, obtuse segments, the terminal one larger and one- to two-toothed.

## PLANTAGINEÆ.

Benth. et Hook. *Gen. Pl.* ii. 1223.

*Fruit and Seed.*—The ovary is superior and syncarpous, consisting of two carpels united to form two cells, or by the development of spurious septa it becomes imperfectly three- to four-celled; in monœcious species it is one-celled. The ovules are solitary, or vary from two to fourteen in each cell in different species, amphitropous, and attached ventrally to axile placentas, the solitary ovule in a one-celled ovary is basal. The fruit is small, included in the persistent calyx, two-celled, two- to many-seeded and dehisces circumscissily below the middle, at, or near the base; when one-seeded it is indehiscent. The seed is peltate and attached by or near the middle to axile placentas or to a basal placenta. The testa is mucilaginous, and swells up in water. Fleshy endosperm is present in variable quantity according to the species. The embryo is generally large and straight, rarely curved, parallel to the hilum, and in one-seeded fruits is erect or transverse. The cotyledons vary in being ovate, oblong or linear, with their backs or edges to the placentas in different species. The radicle is generally and sometimes considerably narrower than the cotyledons, equal in length or more often shorter and inferior. The seeds observed may be conveniently divided into those having the backs and those having the edges of the cotyledons to the axis. The first group is represented by *Plantago media* (fig. 597) which has small, oval, peltate, plano-convex or subconcavo-convex seeds attached to axile placentas. The hilum is below the middle of the ventral face of the seed. The embryo generally lies across the seed diagonally, or oblique to the median axis, and has oblong-spathulate cotyledons lying in the broader plane of the seed with their backs to the hilum or placenta. The radicle is short. The fruit is two-celled and four-seeded. *P. major* has two-celled and eight-seeded fruits with smaller seeds; but the embryo is similarly disposed to that of *P. media*. The cotyledons of *P. major* are oblong and much wider than the terete radicle.

The varieties of this species, namely *P. m. intermedia* and *P. m. asiatica*, conform to the type.

Other species have the cotyledons with their edges to the axis, or placenta of the fruit, as for instance *P. lanceolata* (fig. 600). The ovary is two-celled and four-ovuled, but the fruit bears only one perfect seed in each cell. The seed is comparatively large, occupies the whole of the cell, and is oblong, peltate and deeply concave on the ventral face. The embryo is nearly as long as the endosperm and straight. The cotyledons are linear, semiterete in transverse section, lying in the narrow way of the seed; they almost equal the endosperm in thickness, and have their edges to the placenta. The radicle is shorter and narrower. The object of this arrangement of the cotyledons seems to be for the greater convenience of exit from the seed during germination, because if they had been placed in the broader plane of the seed they might become too wide or even be curved in conformity with the incurving of the sides of the same, when it would be impossible for them to get out. In *P. media*, for instance, where the seeds are nearly flat, the latter do not split open during germination, but the embryo escapes by an opening at one end. In *P. stricta* it closely resembles that of *P. lanceolata*. The fruit of *P. Cynops* is two-celled with one seed in each cell. The seed is ovate, peltate, concave on the ventral face, and has a large suborbicular hilum below the middle of that aspect. The cotyledons are thicker than wide, but their arrangement is precisely that of *P. lanceolata*. The seeds of *P. arenaria* are also solitary in each cell and agree with those of *P. Cynops* in every respect.

Some species whose cotyledons lie in the narrow plane of the seed differ in certain respects from those above mentioned. The seed is not concave on the ventral aspect, but may either be biconvex or plano-convex, and the embryo is relatively very large. *P. Coronopus* is an instance of the former. The seed is broadly oblong with a small hilum below the middle of the ventral face, and is elliptic in transverse section. The cotyledons are linear, as thick as they are wide, and more than semiterete in transverse section, conforming pretty closely to the outline of the seed. The radicle is short

and turbinate. The fruit is two-celled and many-seeded. *P. maritima* differs from the above by having a two-celled, two-seeded fruit, and plano-convex seeds. Endosperm is relatively scanty, and the embryo occupies the greater portion of the seed. In other respects it is similar to *P. Coronopus*.

In comparing *P. media* and *P. Coronopus*, I find that although the cotyledons of the embryos are differently placed with regard to the placentas, they are most conveniently situated in each case to occupy the greatest amount of the area of the seed and more especially during germination. The cotyledons of *P. media* are thin, wide and placed in the broad way of the seed so that they can readily grow wider during germination and also utilise the endosperm around them. The cotyledons of *P. Coronopus* have their edges to the placentas, and their width compared with the combined thickness of the two is as two to three, so that they really occupy a greater area of the seed than if they had their backs to the axis. This is even more evident in *P. maritima*.

*Seedlings*.—Just as there are two leading types of seeds, so are there two distinct types of seedlings with their characteristic cotyledons. The broad general distinction which I adduce from the seedlings coming under my observation is that species with broad many-ribbed leaves have flat, spatulate or lanceolate, but not necessarily very broad cotyledons; while those with narrow leaves, whether entire or divided, have linear and thick succulent cotyledons.

The thin or flat type is represented by *Plantago media* (fig. 598) which has linear-spatulate or lanceolate cotyledons tipped with a dark spot or minutely emarginate, and one-nerved. One or both cotyledons are liable to fission, so that they may be emarginate, bifid or bipartite, sometimes appearing as three or four instead of the normal two. This takes place as a result of growth during germination, and appears to facilitate their exit from the seed. The first leaf is one-nerved; the second trinerved at the base; and the third and fourth are trinerved nearly to the apex. All four are spatulate and hairy. The ultimate leaves are ovate and seven- to nine-nerved. *P. major* belongs to this type.

The second group is represented by *P. Coronopus* (fig. 599)

which has linear, entire, semiterete, thinly pilose cotyledons about 8 mm. long and slightly connate at the base. The first six leaves are similar but larger, longer, and more hairy. The ultimate ones are long, lanceolate, pinnatisect, with linear or lanceolate, pinnatifid or toothed segments, and are trinerved in the lower part, giving off lateral nerves to the segments.

The cotyledons ultimately become succulent and nearly terete. Those of *P. arenaria* differ chiefly in their greater length, measuring from 2–2.6 cm. The leaves are all linear, acute, hairy or pilose, slightly furrowed along the middle, entire, and differ from the cotyledons chiefly in size. The cotyledons of *P. gnaphalioides* conform to those of *P. arenaria* both in shape and size. The leaves are opposite and the first pair resemble the cotyledons. The second pair have one to two obsolete teeth on each side, and the third to the seventh pairs inclusive are linear, broadest above the middle, and obsoletely glandular-dentate. The cotyledons of *P. callosa* vary from 2.8–3.7 cm. in length, and are glabrous, succulent and terete, but otherwise conform to the type. The leaves are linear, entire and alternate. The first one is thinly pilose; the second is larger and slightly furrowed along the middle; the third and fourth are deeply furrowed above and tomentose, followed by two which are broader, deeply channelled above and carinate beneath. The ultimate ones are felted with tomentum and hoary.

***Plantago media*, L. (fig. 597).**

Ovary two-celled, four-ovuled; ovules peltate, amphitropous; micropyle inferior.

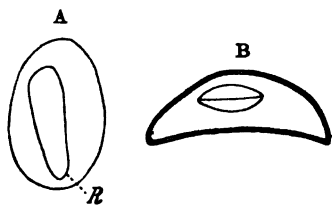


FIG. 597.—*Plantago media*. A, longitudinal section of seed,  $\times 8$ ; R, radicle. B, transverse section of seed,  $\times 16$ .

Fruit capsular, dry, membranous, two-celled, two- to four-seeded, dehiscing circumscissily.

Seeds plano-convex or sub-concavo-convex, peltate, small, oval in longitudinal outline, with equal obtuse ends, or the basal end slightly broader; testa thin, pale brown; hilum a little below the

middle on the ventral aspect, round, deeper brown than the rest of the testa; raphe tapering obliquely from the hilum towards the upper end of the seed.



*Endosperm* copious, fleshy, white.

*Embryo* straight, narrow, colourless, a little shorter than the endosperm and embedded in it a little nearer the dorsal aspect of the seed and somewhat oblique to its median axis; cotyledons oblong-spathulate, plano-convex, tapering towards the base, obtuse, entire; radicle inferior, obtuse, shorter than the cotyledons.

### Seedling (fig. 598).

*Primary root* slender, tapering, fibrous.

*Hypocotyl* tapering downwards, .5–1.4 cm. long, glabrous, pale green.

*Cotyledons* linear-spathulate, or lanceolate, obtuse, tipped with a dark spot or minutely emarginate, tapering into the petiole, glabrous, light green, with a distinct midrib and obscurely reticulate, 1.1 cm. long including the petiole, 2.75 mm. wide, above the middle.

Out of a batch of eight seedlings two had one of the cotyledons more or less deeply bifid or bipartite.

*Stem* very short, constituting the persistent rhizome.

*Leaves* simple, radical, alternate, exstipulate, petiolate, hairy on both surfaces, longitudinally five- to seven- or more -nerved, subplicate longitudinally, and obscurely reticulate between the nerves, light green; petioles broad, more or less winged in the old plant, dilated and sheathing at the base, broadly and shallowly channelled above.

No. 1. Spathulate, obtuse, entire, with a distinct midrib, and obscurely reticulate.

No. 2. Similar, but showing three nerves in the petiole.

Nos. 3 and 4. Similar, but having three nerves extending nearly to the apex.

Ultimate leaves ovate, with short petioles or oval-elliptic, more or less considerably drawn out at the base, five- to seven- or more nerved longitudinally, plicate, obtuse, distantly and obscurely dentate on the sides.

*Germination*.—In eight days fourteen seedlings germinated, and twelve (a percentage of 85.7) carried the testa up with the cotyledons.



FIG. 598.—*Plantago media*.  
Nat. size.

Out of thirty-six seedlings that germinated, one had the one cotyledon entire and the other bipartite, i.e. the seedling had apparently three cotyledons, while another seedling had four such cotyledons. This gives an average of 5.5 per cent. of seedlings with cut or divided cotyledons, but the average might possibly be much greater in a large batch.

***Plantago major*, L.**

*Capsule* two-celled, eight-seeded, ovoid, obtuse, mucronate, glabrous, dehiscing circumscissily about the middle.

*Seed* peltate, oblong, obtuse at either end, variously angled by mutual pressure, convex on both surfaces, especially on the back, smooth, minutely wrinkled or striated, pale green, becoming brownish-green, ultimately black or nearly so; hilum oval, ventral, inconspicuous; micropyle and radicle inferior.

*Endosperm* copious, fleshy, or somewhat horny when dry, colourless.

*Embryo* very similar to that of *P. media*.

***Plantago Coronopus*, L.**

*Ovary* two-celled, many-ovuled; ovules attached below their middle.

*Capsule* ovoid or oblong-fusiform, two-celled, many-seeded, dehiscing circumscissily.

*Seed* oblong-oval, suddenly tapered to an obtuse point at the lower end, small, pale brown, generally suffused with a glaucous colour, dorsally compressed and obtusely apiculate; hilum forming a round, darker-coloured mark on the ventral aspect below the middle of the seed; raphe and chalaza inconspicuous; micropyle at the lower and obtusely pointed end of the seed.

*Endosperm* in the mature seed moderately copious, fleshy, dirty white.

*Embryo* comparatively large, straight, central, nearly equalling the endosperm in length, dirty white or pale brown in colour; cotyledons linear, obtuse, entire, plano-convex, thick and semiterete or even thicker, lying in the narrow way of the seed with their edges to the placenta (the thickening occurring in the broader way of the seed); radicle turbinate, obtusely pointed, much shorter than the cotyledons, lying in the lower pointed end of the seed.

**Seedling (fig. 599).**

*Primary root* tapering, with numerous lateral fibres.

*Hypocotyl* short, mostly subterranean, tapering into the root.

*Cotyledons* linear, obtuse or subacute, with hyaline bristle-like hairs, about 8 mm. long.

*Stem* herbaceous, with undeveloped internodes.

*Leaves* simple, radical, alternate, exstipulate, petiolate in the adult stage, coarsely hairy all over with whitish bristle-like hairs, trinerved in the adult stage, the nerves branching into the primary divisions of the leaf; petiole indistinguishable from the leaf in the seedling stage, trinerved and grooved in the adult, hairy, dilated and sheathing at the base.

Primary leaves linear, similar to but larger and longer than the cotyledons.

Ultimate leaves lanceolate, entire or more or less deeply pinnatifid; segments oblong, linear or lanceolate, acute, entire or slightly toothed or lobed.

*Germination*.—The seeds germinated in three days.

The radicle is first protruded and soon establishes itself in the ground, sending out root-hairs.

The hypocotyl then emerges, and together with the basal part of the cotyledons forms an arch by which (using the radicle as a fulcrum or holdfast) the upper parts of the cotyledons are pulled out.

The epithelial cells of the seed become mucilaginous in the presence of moisture, and attaching themselves firmly to the soil retain the testa there while the cotyledons are being pulled out. The testa is rarely pulled out of the ground.

The cotyledons emerge from the seed with their edges upward; they are at first closely applied face to face, but gradually diverge and open, and turn their faces upwards to the light, while the tips retain the curve for a considerable time.

### *Plantago arenaria*, W. et Kit.

*Ovary* two-celled, with one peltate, amphitropous ovule in each cell, attached in a depression of the thickened placenta about half way between the base and apex of the cell.

*Capsule* ovoid, dehiscent circumscissily about the middle, two-celled, two-seeded, glabrous.

*Seed* oblong or ovate-oblong, tapering slightly upwards but blunt

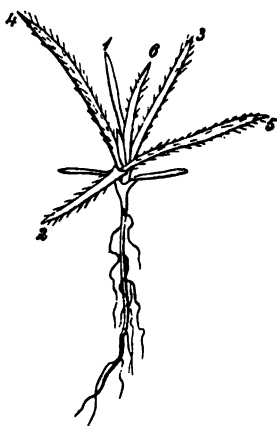


FIG. 599.—*Plantago Coronopus*.  
Nat. size.

at either end, concave or boat-shaped on the ventral face, pale green when immature, becoming deep shining brown, and always semi-transparent, disclosing the embryo ; hilum about the middle of the ventral aspect, oval, whitish ; micropyle and radicle inferior.

*Embryo* straight, colourless, falling a little short of the endosperm transversely to the axis ; cotyledons linear, obtuse, entire, tapering to the base and appearing slightly petiolate, closely applied face to face with their edges to the placenta ; radicle tapering to an obtuse point, thinner and shorter than the cotyledons, but lying in the broader and lower end of the seed.

*Endosperm* abundant, fleshy, somewhat horny when dry, sub-transparent, whitish.

### Seedling.

*Primary root* descending, sending off numerous lateral fibres.

*Hypocotyl* terete, pubescent, 1.2–1.6 cm. long.

*Cotyledons* long, linear, cylindrical or subterete, acute, entire, sessile, with a few scattered minute hairs, green, without any apparent venation.

*Stem* with primary internodes undeveloped.

*First leaves* simple, entire, opposite, radical, linear-acute, slightly furrowed, hairy, green, one-nerved, sessile, exstipulate.

### *Plantago Cynops*, L.

*Ovary* as in *P. arenaria*.

*Capsule* broadly ovoid, mucronate, glabrous, pale green, with a pale line where the two carpels come together, and a dark, slender one along the middle of the carpel giving the capsule in a young state the appearance of consisting of four carpels, two-celled, two-seeded, dehiscing circumscissily near the base.

*Seed* ovate, obtuse, peltate, much compressed dorsally, but convex in conformity with the inner surface of the capsule, concave on the ventral face, smooth, shining, deep green when young with sufficient transparency to show the embryo by transmitted light ; hilum ventral, large, broadly oval or suborbicular, slightly below the middle of the seed ; radicle and micropyle inferior.

*Endosperm* copious, fleshy, rather transparent.

*Embryo* very similar to that of *P. arenaria*.

### *Plantago gnaphalioides*, Nutt.

*Hypocotyl* very similar to last species, glandular-pubescent.

*Cotyledons* as in last species ; slightly connate at the base, with a thin glandular pubescence, 2–2.5 cm. long.

*Stem* annual, terete, erect; glandular-pubescent; 1st internode 1·7–2·6 cm. long; 2nd similar, or somewhat shorter.

*Leaves* cauline, opposite, decussate, tapering to the base, sessile, and slightly connate, with an indistinct midrib, glandular-pubescent, exstipulate.

First pair linear, slender, similar to the cotyledons.

Second pair linear, obtuse, entire, or with one or two obsolete teeth on each side.

Third to seventh pairs linear, broadest above the middle, distantly and obsoletely dentate, teeth glandular.

***Plantago callosa*, Coll.**

*Primary root* very long, flexuose, wiry, annual.

*Hypocotyl* erect, terete, glabrous, deep purple or red, 1·8–2·8 cm. long.

*Cotyledons* linear, acute, terete, glabrous, sessile and connate at the base, forming a cup surrounding the rosette of leaves, 2·8–3·7 cm. long.

*Stem* with the internodes undeveloped.

*Leaves* simple, entire, radical, alternate, sessile, clasping at the base, hoary or felted with a white tomentum.

No. 1. Linear, semiterete, flattened above, very thinly hairy, or pilose.

No. 2. Larger and shallowly channelled above.

Nos. 3 and 4. Tomentose and deeply furrowed above.

Nos. 5 and 6. Broader, tomentose, with a wide deep channel above, and obtusely carinate beneath.

***Plantago lanceolata*, L. (fig. 600).**

*Ovary* two-celled, with axile placentation bearing about midway between the base and apex of each cell two amphitropous ovules; micropyle inferior.

*Capsule* oblong, obtuse at either end, glabrous, two-celled with one perfect seed in each cell, dehiscing circumscissily about one-third above the base.

*Seed* oblong, obtuse at either end, peltate, equalling the interior of the cell in length and breadth, concave on the ventral face and appearing boatshaped, smooth, pale green in the immature state, then becoming colourless or pale yellow and subtransparent, afterwards deep shining brown and still semitransparent when fresh, ultimately deep brown; hilum oval, forming a white or pale spot on the ventral aspect about or a little below the middle; micropyle and radicle inferior.

*Endosperm* abundant, fleshy or somewhat horny when dry, subtransparent.

*Embryo* straight, colourless, embedded in endosperm and falling

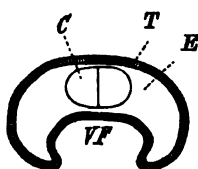


FIG. 600.—*Plantago lanceolata*,  
× 12. Transverse section of  
seed: C, cotyledon; T, testa;  
E, endosperm; VF, ventral  
face.

a little short of the length of the seed; cotyledons narrowly oblong or linear, obtuse, plano-convex, closely applied face to face transversely to the axis, but in the narrow way of the seed, with their edges to the placenta and towards the dorsal and ventral face of the seed, shortly petiolate or tapered downwards; radicle oblong, obtuse, shorter and considerably narrower than

the cotyledons, inferior, tapering downwards.

*Plantago stricta*, Schousb., is very similar to *P. lanceolata*.

*Plantago maritima*, L.

*Ovary* two-celled, with one ovule in each cell.

*Capsule* narrowly ovoid, two-celled, two-seeded, dehiscent circumscissily about one-third from the base; the upper part carrying with it the placentas and seed.

*Seed* oblong-lanceolate, biconvex, or slightly flattened on the ventral face.

*Embryo* straight, large, and nearly occupying the whole of the interior of the seed; cotyledons with their edges to the axis.

## NYCTAGINEÆ.

Benth. et Hook. *Gen. Pl.* iii. 1.

*Fruit and Seed*.—The superior ovary is included in the tube of the perianth, and is one-celled with a solitary, basal, erect, campylotropous ovule. The fruit is a thin, membranous and indehiscent utricle, enclosed in the base of the persistent and now leathery, fleshy or hardened perianth which is termed the anthocarp. The latter is ribbed, furrowed, angled or winged, sometimes mucilaginous, sometimes garnished with stalked glands. The pericarp is sometimes thin and leathery or fleshy. The seed is erect and has a thin hyaline testa, or

the latter may be wholly amalgamated with the pericarp. Endosperm is copious, farinaceous, fleshy or mucous, or scanty, and sometimes almost wanting. The embryo is sometimes straight with broad, foliaceous, conduplicate cotyledons surrounding or enclosing the endosperm, with a short inferior radicle; in other cases it is doubled upon itself with broad, foliaceous, incumbent and convolute cotyledons wrapped round the endosperm; or the cotyledons are narrow and closely applied to the latter. When the embryo is doubled upon itself, the radicle is long, and external to the endosperm, with its tip close to the inferior basal micropyle.

An unusual character occurs in *Cryptocarpus* which has an annular embryo; and in *Abronia* one of the cotyledons is small and almost aborted.

Two different types of embryo occur amongst the seeds observed. The cotyledons are always unequal, but in some cases one is nearly aborted. The anthocarp of *Mirabilis longiflora* is obovoid, closed by constriction above the true fruit, hardened or crustaceous and sculptured on the outer surface. The pericarp is thin and membranous as is the testa which adheres to it. The embryo is doubled upon itself with unequal, concave cotyledons occupying the periphery of the seed and enclosing the farinaceous endosperm. The radicle is long, terete, stout and occupies the other side of the seed, and together with the outer cotyledon determines the smaller size of the inner cotyledon by restricting its growth. The anthocarp of *Oxybaphus nyctagineus* is oblong, obtusely five-angled, hairy and closely invests the fruit, and that again the seed which conforms to the interior. The outer cotyledon is very broad, almost oblate and surrounds the endosperm with its edges closely abutting against the radicle. The inner and smaller cotyledon also comes close up against the radicle with its edges. In other respects this species resembles *Mirabilis longiflora*. The radicle in both cases is curved at its base and longer than the cotyledons.

The second type is represented by *Abronia umbellata* (fig. 602, B). The anthocarp is strongly five-winged with the wings broadest at the upper end. The ovary and seed are

narrowly obovoid or oblong-obovoid, the former slightly oblique at the base where it is attached to the receptacle. The outer cotyledon is broadly ovate-oblong, concave and surrounds the endosperm; the inner one is rudimentary and many times thinner than the petiole of its fellow. The radicle is slightly curved about the middle, longer than the larger cotyledon and occupies the longer side of the seed with its tip occupying the slightly prolonged base. The fruit of *A. arenaria* is ellipsoid and five-angled. The seed is narrowly obovoid. The other characters (fig. 602, A) correspond to those of *A. umbellata*. Occasionally, however, a seed may be found containing an embryo, the smaller cotyledon of which is of some considerable size, and nearly half as long as the other.

*Seedlings*.—As in the seeds so also after germination the cotyledons are unequal. Two leading types may be noticed, namely those which are oblate varying to reniform, and those which vary between oblong and obovate. The more common type of cotyledon is oblate and subtruncate at the base or has a shallow sinus as shown by *Mirabilis dichotoma* (fig. 601). The cotyledons are five-nerved at the base and reticulate, sometimes emarginate with a tooth in the notch. The lamina of the larger one measures 2.2 cm. long and 4 cm. wide, while the smaller one is about the same length, but only 3.6 cm. wide. The petioles are also unequal. The cotyledons of *M. longiflora* are trinerved and reticulate, with the midrib forking some distance below the apex, and they are also variously emarginate. The average size of the larger lamina is 2.38 cm. long and 3.25 cm. wide; that of the smaller one is 1.9 cm. long, and 2.76 cm. wide. The petioles are glandular-pubescent and generally unequal in length. In general characters *M. multiflora* agrees with its congeners. The cotyledons are glabrous and five-nerved; the larger lamina varies in different individuals from 2.4–2.8 cm. long, and 4–4.6 cm. wide; the smaller one is 2.0–2.4 cm. long, and 3.4–3.7 cm. wide.

The seedlings of *Oxybaphus* agree with the above in general form of the cotyledons, but the latter are notable for the shortness of their petioles. Those of *O. viscosus* are relatively small, reniform, trinerved, densely pubescent and unequal.



Those of *O. ovatus* are larger, more decidedly auricled at the base, densely hairy, and sometimes at least unsymmetrical. The first pair of leaves are lanceolate, showing only a midrib, and are hairy like the cotyledons. The latter in *O. elegans* are more roundly reniform, trinerved, glabrous and, like the others, very shortly petiolate. As in *O. ovatus* the short hypocotyl becomes fleshy and tuberous at a very early age. The first pair of leaves are lanceolate, succeeded by others which are ovate and glabrous like the cotyledons. A slight variation occurs in *O. nyctagineus* which has suborbicular, trinerved, glabrous, unequal cotyledons. The lamina of the larger ones measures about 1.5 cm. long, and 1.35 cm. wide, while that of the smaller one is 1.4 cm. long, and 1.3 cm. wide. Both are cuneate at the base.

The species of *Abronia* differ considerably from the above, both in the form of the cotyledons before and during germination, and in their behaviour afterwards. One of the cotyledons is almost aborted in the seed and remains small for some time after germination but in *A. umbellata* at least it afterwards becomes the largest and grows like a leaf, attaining the shape of the latter. The lamina of the larger one eight days after germination is oblong, 8–8.5 mm. long, and 4.5–6 mm. wide; twenty-eight days after germination it is still of the same shape, but is 1.4–1.45 cm. long, and 9 mm. wide. The lamina of the smaller one eight days after germination is obovate, 1.25 mm. long, and 1 mm. wide; twenty-eight days after germination it is 1.4–1.8 cm. long, and 8.75–10 mm. wide above the middle. The leaves are alternate, but the primary ones are nearly opposite. The first four are oblong, somewhat cuneate at the base, and rounded at the apex. The full-grown cotyledons of *A. arenaria* are very unequal. The larger one is oval, 1.4 cm. long, and 8.75 mm. wide, with a petiole 3–4 cm. long, while the smaller one is obovate, 5 mm. long, 3.75 mm. wide, and the petiole 2–2.6 cm. long. The leaves are opposite, but so unequal in size that they appear alternate during development in the bud. They are finely glandular-pubescent, and the first four at least are oval like the larger cotyledon. The ultimate ones are broadly ovate or suborbicular, unequal both in lamina and

petiole. This is brought about probably in part by the procumbent or trailing stem interfering with the proper growth of opposite and decussate leaves.

***Mirabilis longiflora*, L.**

*Hypocotyl* short, stout, erect or decumbent, terete, glabrous or glandular-hairy, 1.5–1.8 cm. long.

*Cotyledons* very like those of *M. dichotoma*, rather fleshy, frequently emarginate with one or two notches, glabrous except the petioles; midrib strong and prominent on the under side; lamina of the larger cotyledon in an average of four, 2.38 cm. long, 3.25 cm. wide; smaller lamina in an average of four, 1.92 cm. long, 2.76 cm. wide; petioles mostly unequal in length, the longer one belonging to the smaller lamina, semiterete, channelled above, densely glandular-hairy, pale green or reddish, 2.6–5.5 cm. long.

*Stem* herbaceous, erect at first, ultimately decumbent, ascending or variable; 1st internode 5–5.5 cm. long.

*Leaves* simple, entire, cauline, opposite, exstipulate, petiolate, irregularly and alternately penninerved and reticulate, with the

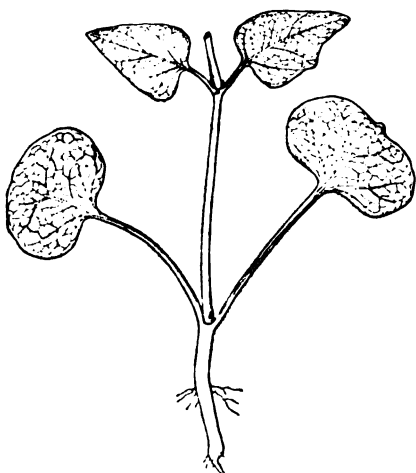


FIG. 601.—*Mirabilis dichotoma*.  
Half nat. size.

nerves forking towards the margin of the leaf, and sending a curved branch downwards and the other upwards to meet the one next above it, more or less glandular-pubescent all over, deep dull green above with a reddish midrib, paler beneath and suffused with red; petioles semiterete, channelled above, densely glandular-pubescent.

First pair ovate, obtuse, suddenly tapered into the petiole.

***Mirabilis dichotoma*, L. (fig. 601).**

*Primary root* very short, apparently ceasing to elongate, and like the hypocotyl giving off fibrous lateral rootlets.

*Hypocotyl* 1.5–2 cm. long, 4 mm. thick, succulent and ulti-

mately becoming fleshy and tuberous, gibbous at the base on one side when young.

*Cotyledons* unequal, transversely oval, apiculate, subtruncate at the base; the larger one 2.2 cm. long, 4 cm. wide, strongly nerved and reticulate; the smaller one 2.2 cm. long, 8.6 cm. wide; petioles 4.8 cm. and 4.3 cm. long respectively.

*Stem* erect and forking from the first pair of leaves, terete, glabrous, bright red; 1st internode 6-9.5 cm. long; 2nd (first of the fork) 1.6-3 cm.

*Leaves*.—First pair ovate, obtuse, irregularly penninerved and reticulate, subtruncate at the base and equal, 3 cm. long and 2 cm. wide; petiole 8-10 mm. long, channelled above, slightly connate at the base.

First pair of the fork ovate, obtuse, constantly very oblique at the base, irregularly penninerved; petiole channelled above, connate at the base, 1-1.5 cm. long.

Second pair of fork triangularly ovate, obtuse, irregularly penninerved and reticulate, pale green on both surfaces; nerves most prominent below; petiole deeply channelled above, convex beneath.

***Mirabilis multiflora*, A. Gray.**

*Hypocotyl* very short or subterranean.

*Cotyledons* unequal, with long petioles, glabrous, pale subglaucous-green, with an oblate lamina; larger lamina 2.4-2.8 cm. long, by 4-4.6 cm. wide, with five nerves radiating from the base, smaller lamina 2-2.4 cm. long and 3.4-3.7 cm. wide, with a similar venation; petioles semiterete, channelled above, finely glandular-pubescent.

*Stem* herbaceous, erect, terete, finely glandular-pubescent; 1st internode 4-4.5 cm. long.

*Leaves* petiolate (upper sessile), ciliate at the margins and pubescent on the nerves beneath, otherwise glabrous, glaucous and suffused with pink; petioles channelled above, finely pubescent.

First pair ovate, obtuse, penninerved, often slightly unequal at the base.

***Oxybaphus nyctagineus*, Sweet.**

*Hypocotyl* very short, subterranean, thickened or tuberous.

*Cotyledons* suborbicular, obtuse, entire, cuneate at the base, trinerved, with the lateral nerves incurved and uniting with the midrib at its apex, unequal, glabrous, rather persistent; lamina of the smaller one 1.4 cm. long, 1.3 cm. wide, and its petiole shallowly channelled on the upper side, and 1 cm. long; lamina of the

larger one 1.5 cm. long, 1.35 cm. wide, with its petiole strongly channelled on the upper side, and 1.15 cm. long.

*Stem* herbaceous, erect, terete, striate, pubescent, purplish; 1st internode about 1.4 cm. long.

*Leaves* simple, entire (at least in seedlings), cauline, opposite, exstipulate, petiolate, glabrous, incurvinerved, with two strong lateral nerves proceeding from near the base as in the cotyledons, tapering downwards into the petiole which is grooved above.

First pair obovate, obtuse, entire.

***Oxybaphus ovatus*, Vahl.**

*Hypocotyl* stout, 1–2 mm. long, glabrous, light green, ultimately tuberous and fleshy.

*Cotyledons* oblate or reniform, unequal, with the larger one unsymmetrical, obtuse, entire, cordate at the base, petiolate, with long thick petioles, hispid, dull green, distinctly pinnatinerved.

*Stem* erect, terete, pubescent; 1st internode 2–3 mm. long.

*First leaves* alternate or nearly opposite, lanceolate, subacute, pubescent, reddish-green; midrib alone apparent.

***Oxybaphus viscosus*, L'Herit.**

*Hypocotyl* erect, terete, finely pubescent, reddish, 7–10 mm. long.

*Cotyledons* very similar to those of *O. ovatus*, thickly pubescent, greenish above, crimson beneath.

The larger cotyledon is cordate at the base, the smaller one only very slightly so, or not at all.

***Oxybaphus elegans*, Chois.**

*Hypocotyl* as in *O. ovatus*, 3–5 mm. long.

*Cotyledons* very similar to those of *O. ovatus*, very unequal, glabrous, light green, trinerved; petiole flat.

*Stem* erect, quadangular, herbaceous; 1st internode 1.5–1.8 cm. long; 2nd 1–2.5 cm.

*First leaves* opposite, decussate.

First pair lanceolate.

Second and succeeding pairs ovate-oblong, obtuse, fleshy, with broad, flat petioles, glabrous, light green above, reddish beneath, distinctly alternately nerved.

***Abronia arenaria*, Menz. (fig. 602, A).**

*Achene* enclosed in and adhering to the ellipsoid, five-angled, persistent base of the perianth.

*Seed* narrowly obovoid, narrowed to the base, where it is slightly unequal, smooth, pale brown, marked from the base to near the apex on each side with a darker brown line; hilum basal in the notch; micropyle close to it, but occupying the longer lobe of the seed in which the radicle lies.

*Endosperm* abundant, mealy or farinaceous, white, lying in the centre of the seed and surrounded, except between the cotyledons and radicle, by the embryo.

*Embryo* large, much curved or doubled upon itself, outside the endosperm, colourless; cotyledons very unequal; the outer one concave or scoop-shaped, lying round the outside of the endosperm which it grasps in its inner concave face, equal in length to the seed; the inner reduced to a small elevation at the base of the petiole of the large one; radicle cylindrical, lying on the outside of the endosperm on the opposite side of it from the cotyledon, slightly tapered to an obtuse tip, pointing to and close to the micropyle, equalling the length of the seed and somewhat longer than the large cotyledon. The smaller cotyledon, however, varies a little in size.

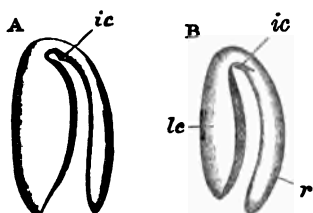


FIG. 602.—A, *Abronia arenaria*. Embryo: *ic*, rudimentary cotyledon,  $\times 6$ . B, *Abronia umbellata*. Embryo,  $\times 6$ : *lc*, larger cotyledon; *ic*, rudimentary cotyledon; *r*, radicle.

### Seedling.

*Primary root* tapering downwards, flexuose, giving off a few lateral rootlets, and growing through the remains of the fruit and anthocarp.

*Hypocotyl* decumbent, thickened towards base of cotyledons, glandular-pubescent, 1.2–2.2 cm. long.

*Cotyledons* very unequal in size of lamina and length of petiole, glandular-pubescent, fleshy; lamina of larger one obovate or oval, 1.4 cm. long, 8.75 mm. wide; petiole 3–4 cm. long; lamina of smaller one obovate, 5 mm. long, 3.75 mm. wide; petiole 2–2.6 cm. long.

*Stem* herbaceous, decumbent or spreading on the ground, densely glandular-pubescent, subsucculent, thickening slightly beneath the nodes, pale green or suffused with red, or flesh-coloured; 1st internode 3.2 cm. long; 2nd 9 mm.

*Leaves* cauline, simple, entire, opposite, unequal, exstipulate, petiolate, glandular-pubescent and deep green above, somewhat paler beneath and densely glandular-pubescent, viscid, penninerved with

the ascending nerves prominent beneath, or three- to five-nerved from the base in the lower half of the leaf; petioles semiterete, flattened or subconvex on the upper surface, gradually tapering upwards, channelled at the insertion of the lamina, densely glandular-pubescent, viscid, fleshy.

First pair small, unequal; one obovate, the other similar but wider.

Second pair unequally developed; large one oval, obtuse, with a lamina 2.3 cm. long, 1.7 cm. wide, and a petiole 4.8 cm. long; smaller leaf rotund, concave, 9 mm. in diameter with a petiole 3 mm. long.

Ultimate leaves opposite, distichous, and all turned to the upper side of the prostrate stem, developing unequally from the bud and always with laminae of a different shape the one from the other, and petioles of unequal length; smaller leaves rotund, slightly cuneate at the base, trinerved in the lower half and arranged alternately; larger broadly ovate, rounded at the end, less frequently broadly oval, obtuse, three- to five-nerved in the lower half, and also alternate.

*Abronia umbellata*, Lam. (fig. 602, B).

*Achene* small, narrowly obovoid, slightly compressed on one side, glabrous, shining, straw-coloured with a brown line running along each side for the greater part of its length, corresponding to the curvature of the ovule; anthocarp five-winged with the wings broadening upwards and tapering cuneately to the base, glabrous; wings nerved and subreticulated transversely.

*Seed* pale-coloured or white; testa thin, membranous; chalaza, hilum and micropyle contiguous, basal; raphe none.

*Endosperm* rather copious, farinaceous, white, forming a mass occupying the centre of the seed.

*Embryo* as in *A. arenaria*.

### Seedling.<sup>1</sup>

*Primary root* very little or altogether unbranched in the early stages.

*Hypocotyl* erect or curved, or decumbent, terete, pale green or pinkish, or reddish, stout, shortly glandular-pubescent, 1-1.8 cm. long, produced into a footlike process at the base on one side, which probably assists in keeping down the fruit while the germinating embryo makes its exit.

*Cotyledons* very unequal immediately and for a considerable time

<sup>1</sup> Figured by Darwin in *Movement of Plants*, p. 95.

after germination, dull green, shortly glandular-pubescent; lamina of larger one eight days after germination oblong, 8-8.5 mm. long, 4.5-6 mm. wide, and twenty-eight days after germination oblong, 1.4-1.45 cm. long and 9 mm. wide; lamina of the smaller one eight days after germination obovate, 1.25 mm. long, 1 mm. wide, sessile or subsessile, and twenty-eight days after germination obovate, tapering to the base, 1.4-1.8 cm. long and 8.75-10 mm. wide above the middle; petiole of the larger one eight days after germination 5.25-12.5 mm. long, and twenty-eight days after germination 2.4-2.8 cm. long, semiterete, flattened on the upper side; petiole of the smaller one eight days after germination very small or almost absent, but twenty-eight days after germination 2.5-3 cm. long, terete, and slightly channelled at the apex only.

The larger cotyledon eight days after germination exhibits a distinct midrib and two lateral nerves near the base, but twenty-eight days after germination the cotyledon becomes rather fleshy, and has the midrib only discernible; the smaller cotyledon at first exhibits a midrib only, and that very indistinctly, but twenty-eight days after germination it is obovate, tapered to the base and trinerved, about the same size as the originally large cotyledon or larger, with a longer or shorter petiole. In all these characters it seems to behave like a true leaf, but maintains the position of a cotyledon.

Fifty-six days after germination the originally large cotyledon measured as follows:—Petiole 2.7 cm. long, with the lamina 1.85 cm. long, 1.1 cm. wide; the originally small one now the largest, with a lamina 2.8 cm. long, 1.2 cm. wide, and its petiole 4.9 cm. long, faintly trinerved.

*Stem* herbaceous, annual, erect at first, ultimately procumbent; primary internodes undeveloped or very little developed in the early stage, but afterwards the first one elongates in different individuals from 5-18 mm.

*Leaves* radical and cauline, alternate, or primary ones almost opposite, shortly and densely glandular-pubescent, alternately and ascendingly penninerved, rather fleshy, with the smaller nerves indistinct or altogether indiscernible; petioles terete, tapering somewhat upwards, densely and shortly glandular-pubescent.

No. 1. Oblong, obtuse, entire, suddenly tapered into the petiole, with about two alternate, indistinct nerves on each side of the midrib, best seen on the under surface.

Nos. 2 and 3. Similar, but somewhat larger with three to four nerves on each side of midrib.

No. 4. Similar, with four to five nerves on each side of midrib.

## ILLECEBRACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 12.

• *Fruit and Seed*.—The ovary is superior, ovoid, or globose, one-celled, with sometimes a slender thread running through it, and contains one, rarely two amphitropous, anatropous, or semi-anatropous ovules, which are erect, pendulous, or inverted and suspended from a basal funicle. The fruit is a utricle enclosed in the perianth, and is rarely nut-like, crustaceous, membranous, indehiscent, or torn at the base, and one-seeded. The seed is erect or inverted, ovoid, clavate, orbicular or lenticular. The testa is thinly membranous, without an aril, enclosing a mealy or fleshy, copious or scanty endosperm. The embryo is sometimes annular surrounding the endosperm and has narrow cotyledons. The radicle is elongated and incumbent, superior or inferior, sometimes dorsal and club-shaped, straight or slightly incurved and closely applied to the oblong cotyledons.

The fruit of *Corrigiola* is a nut with a crustaceous pericarp, and is globose or ovoid-trigonus. The cotyledons are narrow, and the radicle is superior. In *Achyronychia*, *Habrosia*, and *Pollichia* the ovary contains two or four ovules.

The fruit of *Herniaria* is one-celled and one-seeded. The seed is roundly obovoid or almost globular, basal, erect, and anatropous or subanatropous. The embryo (fig. 605) is peripheral to the endosperm and curved round one side of the seed and across the top where the cotyledons form a sort of a hook. The cotyledons are linear, semiterete, about the same breadth and length as the radicle, and lie in the narrow plane of the seed with their backs facing the hilum. The ovule of *Scleranthus annuus* is also solitary but campylo-tropous and suspended from a filiform basal funicle with the hilum and micropyle superior. The embryo is peripheral lying in the narrow way of the seed which it almost entirely surrounds, with a short superior radicle and linear, semiterete incumbent cotyledons facing the basal placenta. The cotyledons are slightly broader than the radicle and about twice as



long. The seed and fruit are ovoid and conform to the interior of the urceolate hardened perianth-tube which is surmounted by the four- to five-lobed lamina.

*Seedlings*.—As the seeds are small the seedlings arising from them are also small and the cotyledons of simple types. Two distinct forms have come under my notice, namely linear-oblong and broadly ovate cotyledons. Those of *Illecebrum verticillatum* (fig. 608) are linear-oblong and tapered to the base where they are slightly connate. The leaves are opposite and the first three pairs linear-spathulate and tapered to the base like the cotyledons, which they resemble, except that they are wider at the apical end. The cotyledons of *Herniaria hirsuta* (fig. 606) are twice or three times as long, more decidedly petiolate, and show an obscure midrib, but otherwise conform to the above type. The persistent perianth-tube is hairy externally, and serves by that means to retain itself in the ground, thus holding down the fruit and testa of the seed while the embryo is able to get clear. In a few cases, however, if these investments have not been fairly well covered with soil, they are carried up on the cotyledons during germination. The cotyledons are sessile at first and gradually develop short petioles by subsequent growth. When the fruit and seed are carried up, the cotyledons make their exit at first by the mere act of lengthening, then one gets perfectly clear by spreading out to the light, while the other carries the empty husks for some time. A somewhat similar process takes place in *Scleranthus annuus* where the cotyledons are similar in shape to those of *Illecebrum verticillatum*, but are more strictly linear and one-nerved. In *Paronychia dichotoma* (fig. 604) the cotyledons are broadly ovate. They are distinctly petiolate, without discernible venation and measure 2.5 mm. in length, and 2 mm. in width. The leaves are opposite, glabrous, and the two first pairs are oval or elliptic and

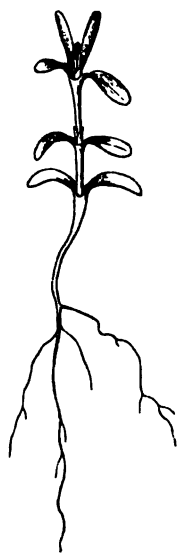
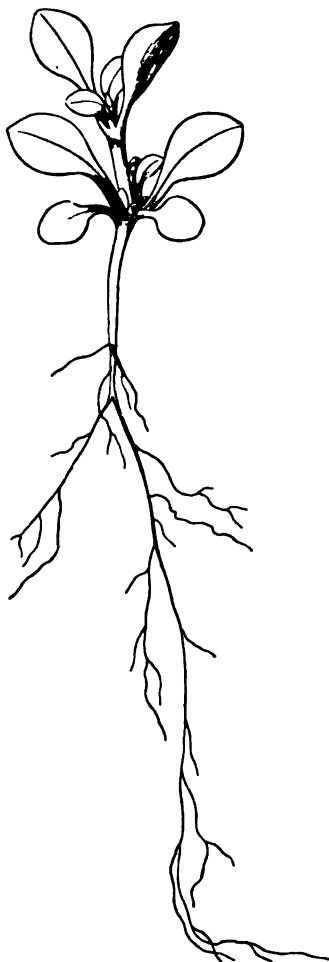


FIG. 608.  
*Illecebrum*.  
*verticillatum*,  $\times 8$ .

taper into a petiole which is slightly connate at the base. They therefore correspond to the cotyledons in being broad, just as both sets of organs are relatively narrow in the above-mentioned species.

*Illecebrum verticillatum*, L. (fig. 603).



*Primary root* slender, fibrous, annual.

*Hypocotyl* erect, ultimately procumbent, tapering downwards, glabrous, pale green or stained red, 3-5 mm. long.

*Cotyledons* linear-oblong, obtuse, entire, sessile, tapering to the base and slightly connate, glabrous, light green, 2.25-2.75 mm. long.

*Stem* erect, soon becoming prostrate, annual, slender, terete, leafy, glabrous, pale green; 1st internode 2.5-3 mm. long; 2nd 2.5-3.5 mm.

*Leaves* simple, entire, cauline, opposite and verticillate, stipulate, sessile, glabrous, narrowed to the base, with an indistinct midrib, slightly connate; stipules small, scarious, more or less united and sheathing the stem, in the axils of the leaves, but interpetiolar in their insertion.

First, second and third pairs linear-spathulate, obtuse, tapering much to the base.

*Paronychia dichotoma*, Nutt. (fig. 604).

*Primary root* very slender, long, tapering, with fibrous lateral rootlets.

*Hypocotyl* erect, terete, glabrous, but scabrous or covered with numerous minute crystalline excrescences, short and tapering indistinguishably into the radicle.

FIG. 604.—*Paronychia dichotoma*,  $\times 8$ .

*Cotyledons* broadly ovate or rotund-ovate, obtuse, entire, gla-

brous, deep green, opaque, without any distinguishable midrib or other nerves; lamina 2.5 mm. long, 2 mm. wide; petiole flattened above or slightly grooved, scabrous on the midrib beneath, 1 mm. long, connate at the base.

*Stem* annual, erect, terete, glabrous, pale green; 1st internode undeveloped; 2nd 1-2.5 mm. long.

*Leaves* simple, entire, radical and cauline, opposite, stipulate, petiolate, glabrous, dark opaque green; petiole flattened above, scabrous on the midrib beneath, subconnate at the base; stipules interpetiolar, scarious, small, united in pairs.

First and second pairs oval or elliptic, obtuse.

***Herniaria hirsuta*, L. (fig. 605).**

*Ovary* one-celled, one-ovuled; ovule basal, erect, anatropous; radicle inferior.

*Fruit* an achene, or utricle, somewhat obovoid, laterally compressed, glabrous, pale-coloured, tipped with the short persistent style and stigma, enclosed in the persistent, comparatively large, hairy calyx, one-celled, one-seeded, indehiscent.

*Seed* erect on a basal funicle, obovate-rotund or almost orbicular, laterally compressed, very minute, glabrous, black, shining; testa crustaceous, comparatively thick; hilum close to the base and oblique; raphe and chalaza inconspicuous; micropyle basal and contiguous to the hilum.

*Endosperm* farinaceous, pale, subtransparent white, confined to a space between the embryo and that side of the seed on which is the hilum.

*Embryo* comparatively large, curved round one side of the seed, outside the endosperm, and across the upper end, colourless; cotyledons linear, obtuse, entire, plano-convex or semiterete, lying in the narrow plane of the seed with their backs to the axis or the hilum, not broader than the radicle, curved; radicle terete, less curved than the cotyledons, and equal to them or slightly shorter, suddenly narrowed to an obtuse point.

*Germination*.—The solitary seed is retained in the achene, and that again in the perianth when the whole falls to the ground at

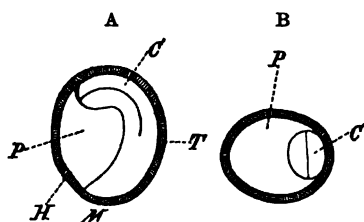


FIG. 605.—*Herniaria hirsuta*,  $\times 80$ .  
A, longitudinal section of seed. B, transverse section of seed: P, endosperm; H, hilum; M, micropyle; T, testa; C, cotyledon.

maturity. The hairy perianth serves to retain the fruit in the ground during germination so that the cotyledons are able in most cases to pull themselves out, clear of everything. When the seed has been rubbed out of the perianth before sowing, the testa is usually carried up. If this happens the cotyledons are then left to their own resources in making their exit, and by growth in length are able to push themselves out and then spreading open to receive the light; the testa is often carried away on one cotyledon. The testa splits vertically a little way, and although it gapes somewhat it continues to hold on to the tip of the cotyledon for some time.

**Seedling (fig. 606).**

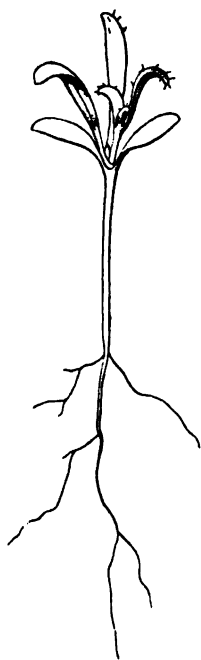


FIG. 606.  
*Herniaria hirsuta*,  $\times 2$ .

*Primary root* tapering, fibrous, normal.

*Hypocotyl* erect, terete, glabrous, almost colourless, 1.2–1.6 cm. long.

*Cotyledons* at first lanceolate-oblong, obtuse, entire, glabrous, somewhat convex above and curved or arched, light green, sessile on germination and 1.25 mm. long, ultimately oblong-linear from 3.5–8 mm. long, 1.25 mm. wide, and shortly petiolate.

*Stem* herbaceous, procumbent, terete, scabrous or rough with little points; 1st internode undeveloped; 2nd short, 1–5 mm. long.

*Leaves* simple, entire, radical and cauline, opposite, stipulate, petiolate, with an indistinct midrib best seen on the under side, unequally developed (one in advance of the other); petioles plano-convex or bi-convex, short; stipules small, toothlike, scarious, minutely ciliate.

First and second pairs spathulate-linear, obtuse, tapering to the base, rough on the midrib beneath, or raised into little tubercles, more or less hairy.

## AMARANTACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 20.

*Fruit and Seed.*—The ovary is superior, ovoid, ellipsoid, or globose and frequently compressed, one-celled and membranous, rarely coriaceous or fleshy. The ovule is fleshy, solitary except in the tribe Celosiæ where there are two or many, erect or pendulous from a basal funicle and amphitropous. The fruit is a membranous utricle, rarely fleshy, and bursts irregularly or circumscissily. The seed is erect or inverted and suspended from a long funicle, lenticular, oblong or reniform-orbicular and mostly compressed laterally. An aril is sometimes though rarely present. The testa is crustaceous or coriaceous, frequently black or brown or shining. The endosperm is copious, farinaceous and often adheres to the inner and membranous coat of the seed. The embryo is slender and curved round the periphery of the seed with incumbent cotyledons and an elongated superior or inferior radicle. In some cases the cotyledons are broad, thin, concave, and unequal, the larger one folding over the smaller.

An exceptional case occurs in *Digera* where the fruit is nutlike. A good type of the Order is represented by *Amarantus hypochondriacus* (fig. 607) which has a lenticular broadly elliptic or suborbicular seed with a peripheral circinate embryo. The cotyledons are linear, plano-convex, of the same length as the radicle, but slightly wider, and they lie across the narrow plane of the seed.

*Seedlings.*—The cotyledons vary between linear and lanceolate, and are often tinged or coloured red, pink, or violet, a peculiarity which is also characteristic of the leaves of many species in this Order. Those of *Amarantus hypochondriacus* (fig. 608) are linear-oblong, subcuspidate, one-nerved and petiolate as in other species.

The cotyledons of *A. polygamus* are slightly broader, lanceolate-oblong, and obtuse. The first two leaves are roundly ovate, emarginate at the base, and followed by four others which are larger and tend to be cordate at the base.

*Scleropus amaranthoides* has linear-oblong cotyledons and a hypocotyl varying from 1–2·7 cm. in length. The first four leaves are oblong, cuneate at the base, emarginate and much narrower than those of the above species; in the latter the venation is strongly incurved.

***Amarantus hypochondriacus*, L. (fig. 607).**

*Ovary* one-celled, one-ovuled; ovule basal, vertical, campylo-tropous; micropyle inferior.

*Fruit* a pyxidium, small, ovoid, pale-coloured, glabrous, thin-walled, one-celled, one-seeded, dry, dehiscing transversely about the middle.

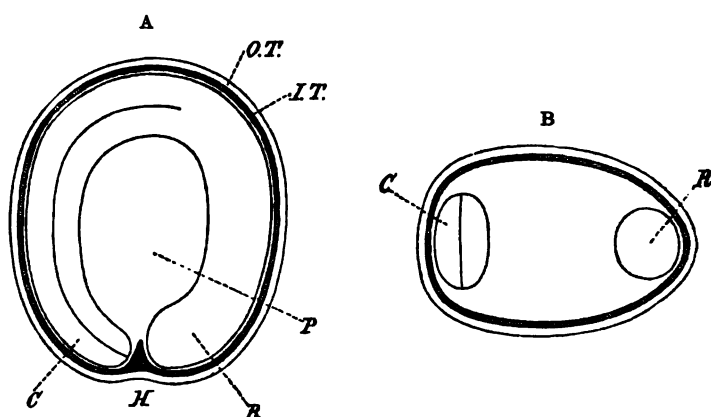


FIG. 607.—*Amarantus hypochondriacus*,  $\times 28$ . A, vertical section of seed: C, cotyledon; H, hilum; R, radicle; P, endosperm; O.T, testa; I.T, tegmen. B, transverse section of seed: R, radicle; C, cotyledon.

*Seed* lenticular, broadly elliptic or more often orbicular in outline with a minute notch at the base, biconvex, deep brown or black and shining when mature, glabrous; testa crustaceous, brittle; tegmen very thin, membranous, white; hilum and micropyle contiguous, basal; raphe none.

*Endosperm* white, farinaceous, forming a very thin layer at the periphery of the seed, and surrounding the embryo, but forming a much larger mass within the curved embryo.

*Embryo* comparatively long, narrow and slender, much curved round and just within the extreme circumference or periphery of the endosperm, colourless; cotyledons incumbent, linear, obtuse, slender, plano-convex, lying in the narrow plane of the seed with their backs

to the placenta, about equal to the radicle in length; radicle filiform or terete, curved round the periphery of the seed till it almost meets the tips of the cotyledons at the base of the seed and close to the hilum.

**Seedling (fig. 608).**

*Radicle* long, tapering downwards, slightly flexuose, with fibrous lateral rootlets, pink or flesh-coloured, annual.

*Hypocotyl* erect, terete, glabrous, deep red, 7-12 or 14 mm. long.

*Cotyledons* linear-oblong, obtuse, entire, subcuspidate, glabrous, one-nerved, petiolate, green and more or less suffused with red or pink, especially along the midrib; lamina tapering into the petiole, 6.5-10 mm. long, 2.5-3 mm. wide; petiole flat or slightly grooved above, convex beneath; 2-3.5 mm. long.

*Stem* herbaceous, annual, erect, terete, or more or less angled, or ridged and furrowed, slightly hairy, red; 1st internode 3.5-8.5 mm. long; 2nd 2.5-7 mm.

*Leaves* simple, entire, cauline, alternate, exstipulate, petiolate, slightly hairy and glandular on both surfaces when young, afterwards glabrescent, alternately penninerved with the nerves incurved towards their apex and uniting with one another by slender branches only; petioles semiterete, channelled above, and with the edges of the lamina decurrent and forming a very slender wing on the upper half, slightly hairy when young, especially on the upper edges, decurrent on the stem and forming ridges.

Nos. 1 and 2. Oval or elliptic, obtuse, entire or emarginate, green, or more or less stained with red.

Nos. 3-6. Oval, emarginate, with a bristle-like mucro in the notch, gradually larger, undulate at the margin when young, green or more or less stained with red.

***Amarantus polygamus*, L.**

*Primary root* long, stout, fleshy, tough, pink, with numerous lateral rootlets.



FIG. 608.—*Amarantus hypochondriacus*.  
Nat. size.

*Hypocotyl* as in last species, deep violet red, 1·4 cm. long.

*Cotyledons* violet-red, greenish above, glabrous; lanceolate-oblong, obtuse, 1 cm. long, 4 mm. wide; petiole channelled above, 8·5 mm. long.

*Stem* herbaceous, annual, erect, angled, deep violet-red, pubescent; 1st and 2nd internodes 1 mm. long; 3rd 3 mm.; then numerous crowded internodes follow.

*Leaves* glabrous, thickened and slightly scabrous at the margin, subplicate, deep violet-red suffused with green above; petioles deeply channelled above, striate on the back, with raised or slightly winged margins alongside the channels, somewhat curved on the lower side at their insertion on the stem, slightly pubescent.

Nos. 1 and 2. Rotund-ovate, very obtuse, emarginate, subcuneate at the base.

Nos. 3-6. Rotund-ovate, very obtuse, emarginate, subcordate at the base.

Ultimate leaves ovate, retuse, apiculate, subdecurent on the petiole at the base, glabrous, crisped at the margin, greenish-purple with crimson petiole, and nerves beneath.

*Scleropus amaranthoides*, *Schrad.*

*Hypocotyl* erect, terete, glabrous, 1-2·5 cm. long, stained with red.

*Cotyledons* linear-oblong, obtuse, entire, petiolate, membranous, glabrous, green, often tinged with red beneath, distinctly one-nerved.

*Stem* erect, terete, angled, herbaceous, glabrous; 1st internode 4-6 cm. long; 2nd and 3rd shorter.

*First leaves* simple, cauline, alternate, petiolate, exstipulate, oblong, entire or slightly emarginate, glabrous, pale green tinged with red beneath, distinctly alternately pinnatinerved.

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## CHENOPODIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 43.

*Fruit and Seed.*—The ovary is superior, quite free or immersed in the receptacle at the base only, but included in the perianth when that is present, ovoid, or globose and depressed, rarely oblong or flask-shaped, and one-celled. It is syncarpous and made up of two to three carpels. The ovule is solitary, basal and erect, or suspended from a long funicle, and



amphitropous. The fruit is a utricle, membranous, coriaceous, or fleshy, generally included in the perianth and falling with it, indehiscent, rarely circumscissile, free or adhering to the testa. The seed is erect, inverted or horizontal, lenticular, subglobose, reniform or ovoid-compressed. The testa is crustaceous, leathery, fleshy or membranous, sometimes adhering to the endosperm, and consisting of a single or double layer. The endosperm is farinaceous, fleshy or wanting. The peripheral embryo is annular or horseshoe-shaped and surrounds the endosperm; it is rod-like and dorsal in the tribe Salicorniæ, or conduplicate and in the absence of endosperm occupies the whole seed. Endosperm is wanting in the tribe Salsolæ and others when the embryo is flat or coiled like a shell. The cotyledons are, however, mostly narrow, plano-convex, or flat in a few, and slightly wider than the elongated radicle.

The seeds of *Chenopodium Bonus-Henricus* (fig. 609) are reniform, small and black with a crustaceous testa. The embryo entirely surrounds the periphery of the endosperm except a small portion at the hilum. The cotyledons are linear, plano-convex, lying in the narrow plane of the laterally compressed seed, incumbent, of the same length as the radicle, but slightly wider. The seed of *Beta trigyna* is globoso-reniform, grooved along one side, laterally compressed and often angular. It is suspended from near the apex of the utricle, and the superior radicle is shorter and thinner than the width of the cotyledons. The basal auricles of the seed are oblique or unequal.

The seeds of *Atriplex hortensis* are of two sizes, the small ones being black and similar to those of *Chenopodium Bonus-Henricus*, while the larger ones are brown and more orbicular. The large brown ones germinate much more quickly than the small black ones, which would seem, under natural conditions, to be more adapted to remain in a resting condition in the ground during the winter, and germinate in spring. If such is the case they would enable the plant to exist in a colder climate than the large ones would. Of a sowing made on October 29, one black seed germinated in four days, and three days later no more had come up, whereas thirty-two of the large brown seeds germinated in the seven days. On November 16, a sowing was made of thirty-five each of the black

and brown seeds. In the course of six days, five of the brown seeds germinated, and only one black seed in the course of thirteen days, whereas by that time twenty-three of the brown seeds had germinated. Twenty-three days after being sown, ten of the black seeds had germinated, and twenty-six of the large brown ones. The seed of *Chenopodium petiolare* is small and orbicular and laterally compressed, but in other respects resembles that of *C. Bonus-Henricus*.

*Seedlings*.—The cotyledons coming under my notice are all of simple types, notwithstanding the difference in the seeds. Two of the types cannot be separated by hard and fast lines, as they gradually merge the one into the other. One of the simplest and widely prevailing forms is represented by *Chenopodium Bonus-Henricus* (fig. 610) which has linear-lanceolate cotyledons tapered gradually into petioles which are slightly connate at the base. The first two leaves are ovate, the third roundly cordate. The cotyledons of *C. Quinoa* are shorter and broader and, like the above, one-nerved. The first three leaves are oblong and mealy. The cotyledons of *Blitum virgatum minus* are small, linear and petiolate. A rather interesting evolution is shown by the leaves. The first is linear, the second spathulate, the third oblong, the fourth and fifth lanceolate-hastate, the sixth and seventh hastate, and the eighth to the twelfth inclusive cuneate, trifid, and trinerved. These characters vary, however, in different seedlings according to the vigour of the same. The cotyledons of *Atriplex hortensis* are similar to those of *Blitum virgatum minus*. The leaves are opposite, the two first pairs being oblong-ovate, followed by three other pairs which are triangular and variously toothed, angled, or hastate.

A relatively broader type is represented by *Chenopodium ficifolium* which has oblong-lanceolate, petiolate, one-nerved cotyledons. The two first leaves are opposite and oblong, followed by five which are alternate and lanceolate. The eighth to the thirteenth are more or less hastate, and in robust seedlings most of the primary ones show a tendency to be hastate. The cotyledons of *Chenopodium viride* are oblong, obtuse and mealy. The first pair of leaves are similar but broader. The cotyledons of *Blitum virgatum* (fig. 611) are

lanceolate with long petioles. The first pair of leaves are lanceolate and subhastate.

*Beta vulgaris* has linear-oblong or spathulate cotyledons, and the first pair of leaves are broadly oval. *Atriplex oblongifolia* has elliptic-oblong, obtuse cotyledons, and the first pair of leaves are sagittate.

A number of seedlings are notable for the great length of their linear cotyledons. An instance of this is *Spinacia oleracea*. The first pair of leaves are broadly oval. The cotyledons of *S. glabra* (fig. 612) are much longer, more truly linear, and measure from 3 to 8 cm. in length. Those of *Threlkeldia rostrata* (fig. 613) are linear, fleshy, glandular-pubescent and recurved. The first thirty leaves at least are linear, fleshy and narrower than the cotyledons. The latter in *Salsola Tragus* are linear, semiterete, fleshy and 2.6–3.5 cm. long. The leaves are all terete and fleshy.

The most remarkable type I have noticed is that of *Basella alba* (fig. 614). The genus according to some authors constitutes the type of a distinct Order. The cotyledons are oblong, obtusely pointed, almost sessile, and fleshy with a few indistinct nerves on each side of the midrib, 5.9 cm. long and 2.2 cm. wide. The first two leaves are opposite or nearly so, broadly oval and obliquely emarginate.

***Chenopodium petiolare*, H. B. K.**

*Ovule* campylotropous.

*Seed* small, from .25–.5 mm. long, orbicular and somewhat laterally compressed; testa smooth; hilum inconspicuous.

*Endosperm* rather copious, central, surrounded by the peripheral embryo, greyish.

*Embryo* as in *C. Bonus-Henricus*.

***Chenopodium Bonus-Henricus*, L. (fig. 609).**

*Ovule* vertical or rather horizontal, amphitropous; micropyle inferior.

*Fruit* a utricle, one-celled, one-seeded, indehiscent, small.

*Seed* reniform, subcompressed laterally, smooth, shining, black; testa crustaceous; hilum basal.

*Endosperm* floury, white, forming a mass on the basal side and centre of the seed, and a thin film round the periphery and between the embryo and the outer ridge of the seed.

*Embryo curved and following the vertical ridge of the seed, and equal in length to this circumference; cotyledons linear, obtuse,*

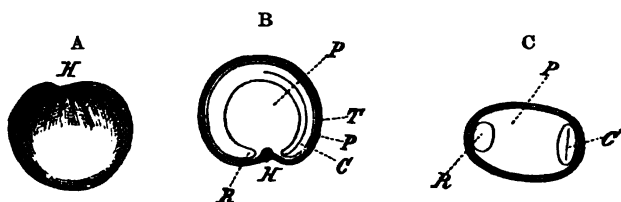


FIG. 609.—*Chenopodium Bonus-Henricus*,  $\times 8$ . A, seed. B, vertical section of seed. C, transverse section of seed: H, hilum; R, radicle; C, cotyledon; P, P, endosperm.

plano-convex, lying in narrow plane of the seed; radicle cylindrical, obtuse, about equal in length to the cotyledons, with its tip close to the hilum as are the tips of the cotyledons.

### Seedling (fig. 610).

*Primary root tapering downwards, and giving off fibrous lateral rootlets.*



FIG. 610.—*Chenopodium Bonus-Henricus*.  
Nat. size.

*Hypocotyl erect, terete, glabrous, red, 1-2 cm. long.*

*Cotyledons linear-lanceolate, obtuse, entire, tapered gradually into a long petiole, which is connate with its fellow at the base, forming a little cupule from which the plumule emerges, glabrous, green, traversed longitudinally by a distinct midrib, about 3 cm. long including the petiole; petiole flattened above or slightly grooved, convex on the back.*

*Stem herbaceous, developed when about to flower; primary internodes undeveloped.*

*Leaves simple, radical and cauline, alternate, exstipulate, petiolate, glabrous, more or less farinose, especially on the under side, the petioles and the young leaves, alternately and ascendingly*

penninerved, obscurely reticulate ; petioles semiterete, rather deeply and narrowly channelled above, dilated and clasping at the base, tapering upwards.

Nos. 1 and 2. Ovate, obtuse, entire, cuneate at the base with lateral ascending nerves, incurved at their apices and uniting within the margin.

No. 3. Roundly cordate, obtuse or cuspidate, with rounded obtuse auricles at the base.

***Chenopodium Quinoa*, Willd.**

*Hypocotyl* about 4 cm. long, light green or colourless, with a reddish tinge near the ground.

*Cotyledons* linear, obtuse, entire, 1-1.6 cm. long, tapering to the base but scarcely petiolate, thick, fleshy, glabrous, dark green, one-nerved.

*Stem* herbaceous, erect, terete, light green, glabrous or slightly mealy towards the leaves ; 1st internode 9-10 mm. long ; 2nd considerably shorter.

*First leaves* entire, cauline, opposite, decussate, shortly petiolate, oblong, obtuse, mealy, light green ; midrib with numerous lateral veinlets.

***Chenopodium ficifolium*, Sm.**

*Primary root* as in *C. Bonus-Henricus*.

*Hypocotyl* becoming stouter upwards, glabrous, shining, brownish red, 1.5 cm. long.

*Cotyledons* caducous, oblong-lanceolate, obtuse, fleshy, petiolate, 6 mm. long including petiole.

*Stem* erect, terete, succulent, herbaceous, glabrous and shining towards the base, striped with red lines on a pale green ground, farinaceous upwards ; 1st internode 5.5 mm. long ; 2nd 6.5 mm. ; 3rd 8 mm. ; 4th 2.5 mm. ; 5th 3 mm. ; 6th 2 mm. ; 7th 2 mm.

*Leaves* cauline, alternate (first two opposite), petiolate, densely farinose when young, glabrescent above at an early period, and later on the under sides, bright green above when developed, paler beneath, subsucculent or fleshy ; petioles subterete, slightly channelled above, farinose, glabrescent.

Nos. 1 and 2. Opposite, oblong, obtuse, entire.

No. 3. Lanceolate-oblong, obtuse, slightly bidentate at the base.

No. 4. Lanceolate, obtuse, with one tooth near the base.

No. 5. Similar, but larger.

No. 6. Lanceolate, obtuse, subhastate, cuneate at the base.

No. 7. Similar, but larger.

No. 8. Oblong, obtuse, subhastate, cuneate at the base and distantly serrate above the basal lobes.

No. 9. Hastate, obtuse, cuneate and trinerved at the base.

Nos. 10-18. Similar, or slightly more serrate.

***Chenopodium viride, L.***

*Hypocotyl* thin, 2.5-3 cm. long, tinged with a deep red.

*Cotyledons* oblong, obtuse, fleshy, petiolate, entire, mealy, dark green tinged with red or purple beneath, indistinctly one-nerved.

*Stem* light green, mealy; primary internodes very short.

*First leaves* entire, cauline, opposite, decussate, oblong-oval, obtuse, with short petioles, mealy, light green above, tinged with red beneath, pinnatinerved.

***Beta trigyna, W. et Kit.***

*Ovule* pendulous from a basal funicle, campylotropous; micropyle superior, or pointing a little to one side.

*Fruit* a utricle, agglomerated in masses owing to the flowers being sessile, enclosed in and even adnate to the hardened and persistent perianth, surrounded by its five free persistent segments of the perianth and the cup-like base of the connate stamens, the filaments of which are free upwards, persistent, and folded over the apex of the utricle which is one-celled, one-seeded and indehiscent.

*Seed* subglobose, or somewhat angled or compressed, conforming to the interior of the utricle, notched at the base or subreniform and suspended from a basal funicle, glabrous, shining, black; tegmen rather thinner and paler coloured than the thin and subcrustaceous testa; hilum, micropyle, and chalaza contiguous, basal and superior; raphe none.

*Endosperm* forming a mass lying in the middle of the seed, between the radicle and cotyledons, and also a thin layer between the embryo and the testa, farinaceous and loose when dry, white.

*Embryo* peripheral, comparatively large, much curved, colourless; cotyledons oblong-linear, obtuse, entire, plano-convex, lying in the narrow way of the seed with their edges to the floral axis, longer than the radicle, and very little broader than its thickness, much curved, sometimes twisted; radicle thick, curved, tapered to an obtuse point, embedded in a very thin layer of endosperm and close to the micropyle.

***Beta vulgaris, Moq.***

*Primary root* tapering downwards, with a few fibrous lateral rootlets, red.

*Hypocotyl* scarcely appearing above ground.

*Cotyledons* subfleshy, unequal, linear-oblong, cuneate at the base, shortly petiolate, obtuse, entire, glabrous, green, one-nerved; petioles red, furrowed on the upper face.

*Stem* with primary internodes undeveloped.

*First leaves* simple, entire, radical, alternate, broadly oblong or oval, petiolate, obtuse, glabrous, green, pinnatinerved; petioles short, reddish, furrowed on the upper face.

***Blitum virgatum*, L. (fig. 611).**

*Primary root* nearly vertical, small, brownish, with a few fibres.

*Hypocotyl* herbaceous, terete, glabrous, purplish-red, 1-2 cm. long, 1 mm. thick.

*Cotyledons* petiolate, nearly equal; blade about 1 cm. long, 3 or 4 mm. wide, obtuse, lanceolate, entire, obscurely nerved, thin but fleshy, glabrous, green above, pale beneath; petiole as long as blade, 1 mm. wide.

*Stem* very short until about to flower.

*Leaves* simple, radical and cauline, alternate, exstipulate, petiolate, subfleshy, obscurely or distinctly alternately penninerved, more or less glandular-hairy (at least in the young stage).

Nos. 1 and 2. With shallow-channelled, glabrous, reddish petiole, 1.5 cm. long, 1-1.5 mm. wide, and an obtuse, lanceolate, obscurely basilobed blade, 1.5 cm. long and nearly 1 cm. wide, produced at the base, obscurely penninerved, glabrous, thin but fleshy, dull green above, purplish-red beneath, thinly glandular-hairy.

Nos. 3 and 4. Subhastate, sinuate-dentate, glandular-hairy on blade and petiole.

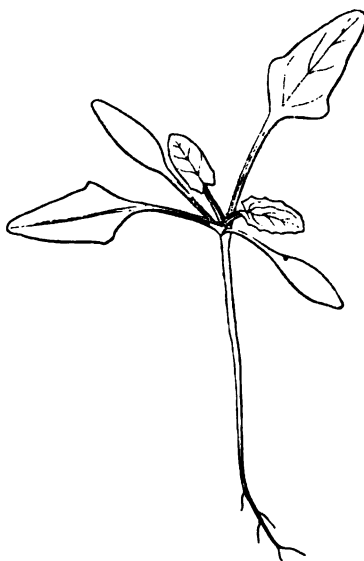


FIG. 611.—*Blitum virgatum*. Nat. size.

***Atriplex hortensis*, L.**

This plant has two forms of seed.

1st. Subrotund, flattened laterally, 2.5-4 mm. in diameter

(usually about 3 mm.), flat or concave on the sides; testa thin, membranous, light brown or straw-coloured, smooth, not shining.

2nd. Subrotund, slightly flattened laterally, 1.5–2.5 mm. in diameter, biconvex; testa rather thick, crustaceous, bright black, smooth and shining.

Both kinds of seed are usually enclosed in the membranous, thin, indehiscent utricle.

In some sowings which I made, the brown seeds came up more quickly than the black, as if the black were intended to remain for a while dormant. The subject, however, requires further study.

### Seedling.

*Primary root* tapering downwards, flexuose, yellowish, with short lateral rootlets, annual.

*Hypocotyl* erect, terete, glabrous, short and merging indistinguishably into the root.

*Cotyledons* petiolate, falling away early, linear, obtuse, about 1 cm. long including the petiole.

*Stem* erect, terete, herbaceous, annual, pale green, glabrous, shining, farinaceous in the upper and younger part; 1st internode 1.5 mm. long; 2nd 3 mm.; 3rd 9 mm; 4th 10.5 mm.

*Leaves* simple, cauline, opposite, or the upper ones alternate, petiolate, mealy when young, smooth and glabrous when mature, pale green, or in the garden variety rubra of a deep reddish-purple especially in the young state, trinerved at the base with a branch from the lateral nerves into the basal lobes; petioles subterete, slightly flattened on the upper side and narrowly channelled, glabrous.

First pair oblong-ovate, obtuse, truncate, and sometimes with a minute lateral tooth on each side at the base, very faintly trinerved.

Second pair similar, but larger.

Third pair in robust specimens triangular, obtuse, minutely and obsoletely dentate or entire, truncate at the base.

Fourth pair triangular, subacute, minutely denticulate, hastate, truncate at the base.

Fifth pair triangular, subacute, sagittate-hastate, more deeply dentate on the lower half.

Ultimate leaves large, triangular, sagittate-hastate, subcuspidate, irregularly repand, serrate-dentate except towards the point, trinerved with a strong branch from the lateral nerves entering the basal lobes.

Uppermost leaves near the inflorescence again becoming smaller and less decidedly cut.



***Atriplex oblongifolia*, W. et Kit.**

*Hypocotyl* 3-6·5 cm. long,

*Cotyledons* elliptic-oblong, entire, obtuse, shortly petiolate, glabrous, dark green, one-nerved.

*Stem* erect, terete, herbaceous, mealy; first internode 2-3 mm. long.

*First leaves* opposite, decussate, sagittate, pinnatifid.

***Spinacia glabra*, Mill. (fig. 612).**

*Hypocotyl* erect, terete, glabrous, 1·5-2·5 mm. long, colourless or tinged with red.

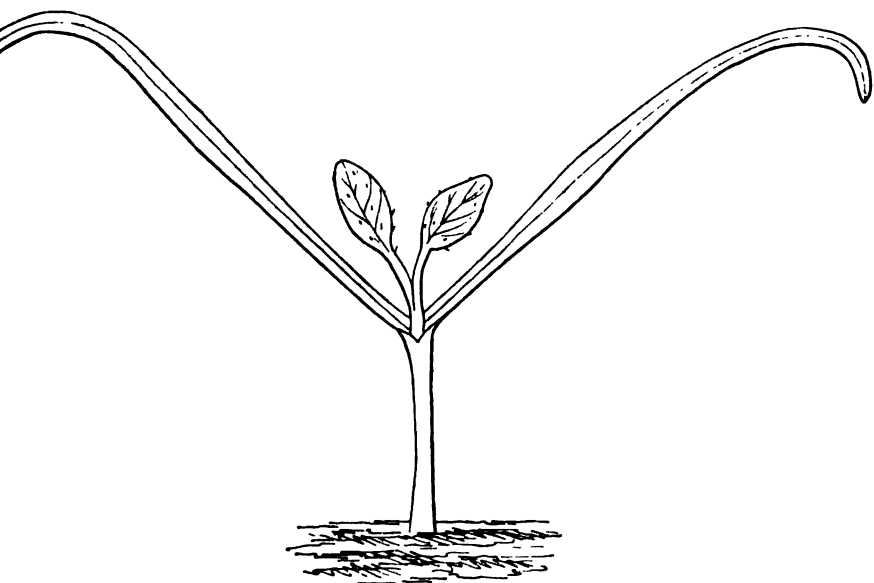


FIG. 612.—*Spinacia glabra*. Nat. size.

*Cotyledons* linear, acute, fleshy, 3-8 cm. long, entire, glabrous, bright green, one-nerved, tapering to the base.

*Stem* erect, herbaceous; primary internodes very slightly developed.

*First leaves* oval or ovate, obtuse, entire, simple, cauline, opposite, petiolate, very slightly mealy above, glabrous beneath, green, pinnatinerved.

***Spinacia oleracea*, Mill.**

*Hypocotyl* thickened upwards, 6–8 mm. long.

*Cotyledons* subfleshy, unequal, linear, subacute, entire, sessile, tapering to the base, glabrous, light green, distinctly one-nerved.

*Stem* with primary internodes undeveloped.

*First leaves* radical, opposite, afterwards alternate, broadly ovate-oblong or oval, obtuse, shortly petiolate, glabrous, light green, pinnatinerved; petioles flattened, channelled on the upper side, glabrous.

***Threlkeldia rostrata*, ? F. Muell. (fig. 618).**

*Hypocotyl* erect, terete, pale green, minutely glandular-pubescent, about 1.6 cm. above the soil.

*Cotyledons* linear, obtuse, fleshy, pale green, sessile, minutely glandular-pubescent, or slightly hairy on the midrib beneath, narrowed to the base and subconnate, 3 cm. long, 3.5 mm. wide.

*Stem* primarily erect, terete, pale green, minutely glandular-pubescent, ultimately subshrubby; 1st internode 4.5 mm. long; 2nd .5 mm.; 3rd 4 mm.; others similar.

*Leaves* simple, entire, cauline, alternate, sessile, minutely and thinly glandular-pubescent, except in the young state when the glandular hairs are more numerous, fleshy, pale green, slightly channelled, linear, obtuse, all similar in the seedling, narrower than the cotyledons.

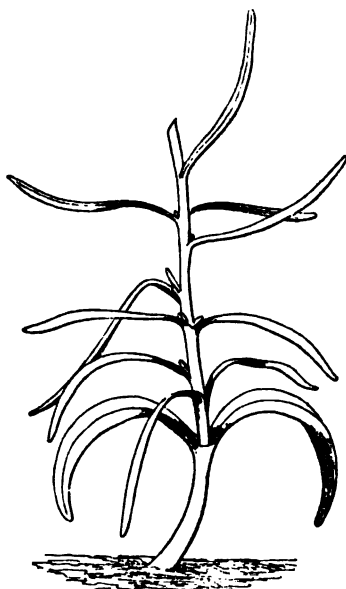


FIG. 618.—*Threlkeldia rostrata*.  
Nat. size.

Nos. 1–80. Linear, obtuse, fleshy, narrow.

***Salsola Tragus*, L.**

*Hypocotyl* slender, or wiry, erect, terete, glabrous, red, 2–4.5 cm. above the soil.

*Cotyledons* linear, obtuse, sessile, fleshy, semiterete, flattened above, sheathing the plumule, that is connate at the base, frequently both directed to one side, glabrous, 2.6–3.5 cm. long.

*Stem* herbaceous, erect, terete, finely ridged and furrowed, striated with red and green, scabrous or coarsely pubescent especially on the ridges.

*Leaves* simple, entire, cauline, terete, tipped with a bristle, fleshy, channelled on the upper side at the base only, which resembles a clasping petiole, and slightly pubescent, otherwise the leaf is glabrous.

First, second, and sometimes more of the lower pairs opposite, while the upper ones are alternate.

***Basella alba*, L. (fig. 614).**

*Hypocotyl* erect, terete, succulent, glabrous, pale green, purplish at the base, 2-3 cm. above the soil, 5 mm. thick.

*Stem* erect, succulent, glabrous, pale green; 1st internode 1 cm. long.

*Cotyledons* large, oblong, obtusely pointed, foliaceous, glabrous, succulent, pale green, obscurely and alternately penninerved, shortly petiolate, 5.9 cm. long including the petiole, 2.2 cm. wide.

*Leaves* simple, cauline, alternate, petiolate, succulent, glabrous, subreticulate, or rather obscurely reticulate, tapering into the short fleshy petiole which is slightly channelled above, and articulated with the stem.

Nos. 1 and 2. Opposite, oval, retuse, somewhat obliquely emarginate.

No. 3. Alternate, otherwise like the first two.



FIG. 614.—*Basella alba*.  
Half nat. size.

## PHYTOLACCACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 78.

*Fruit and Seed*.—The ovary is superior and consists of one or several distinct or connate carpels, inserted on a flat or very rarely elevated receptacle. The ovules are solitary in each carpel, attached by a short funicle to the base of the cavity,

more rarely to the inner angle of the cell, and amphitropous or campylotropous. There is frequently a spongy arillode at the micropyle. The fruit is monocarpellary and crustaceous, coriaceous, baccate or samaroid, or it is polycarpellary, with one-celled, one-seeded, free or connate carpels. The seed is erect, very rarely ascending, and globose, reniform or lenticular and compressed. The testa is membranous or crustaceous, and smooth, rugose or downy. A small bilobed aril is frequently present; but in *Stegnosperma* it is large and covers the seed. The embryo is relatively large, peripheral, and surrounds the farinaceous or fleshy endosperm. In elongated seeds it is hooked or abruptly deflexed at the apex. The cotyledons are incumbent, foliaceous, and plicate-convolute, or linear, narrow and semiterete or plano-convex. The radicle is elongated and close to the hilum.

Some exceptional cases occur in the Order. The ovary is half inferior in *Agdestis*; and in *Stegnosperma* it is one-celled and many-ovuled, while the fruit is three-valved and three- to five-seeded. The large aril of *Stegnosperma* is also notable.

At least three distinct types of seeds have come under my observation. The simplest, represented by *Phytolacca pruinosa*, is exactly similar to what occurs in *Illecebracæ* and *Chenopodiaceæ*. The seed is reniform, laterally compressed with a large peripheral embryo surrounding a moderate quantity of farinaceous endosperm. The cotyledons are linear, plano-convex, slightly wider than the radicle and about twice as long. The seed of *P. acinosa* corresponds closely to that of its congener.

The seed of *Rivina lævis* is small, orbicular, laterally compressed, notched at the base, densely pubescent and unequal in thickness. The embryo is curved, horse-shoe fashion, round the endosperm; but the cotyledons are very wide, thin, longitudinally convolute and somewhat longer than the radicle. The position is best seen in transverse section. A vertical section shows four pieces as if there were four cotyledons.

The fruit of *Petiveria octandra* (fig. 616) is an achene surmounted by two to six sharply reflexed hooks of unequal size. The embryo is sharply doubled upon itself and nearly peri-

spherical on two sides of the seed with the greater bulk of the endosperm occupying the other two sides. The cotyledons are convolute longitudinally, but very unequal. The broader one is outermost, deeply auricled at the base and trilobulate at the apex. The smaller one is much the longest, auricled at the base but otherwise entire, and convolute inside the larger one in its lower half only.

*Seedlings*.—The cotyledons seem always to be broad. Those of *Phytolacca abyssinica* (fig. 618) are lanceolate-ovate, slightly unequal, cuneate at the base, rather fleshy, indistinctly penninerved, 3–5 cm. long, and 1·5–2 cm. wide. The first two leaves are ovate-elliptic.

The cotyledons of *Rivina lævis* (fig. 615) are rotund, subcordate, trinerved, obtusely cuspidate, and reticulate. The primary leaves are cordate. A slight difference occurs in the cotyledons of *R. canescens* which are reniform, slightly unequal, rounded at the apex, trinerved and entire. The first two leaves are ovate.

The cotyledons of *Petiveria octandra* (fig. 617) are very unequal. The shorter one is much the broader, triangular or subcordate, obscurely trilobate at the apex, and otherwise somewhat indented at the sides, but this latter characteristic may not be constant; it is penninerved, with the basal pair of laterals strongly developed. It is about 2 cm. long and 1·75 cm. wide. The longer cotyledon is oblong, obtuse, penninerved, 3 cm. long, and 1·25 cm. wide.

### ***Rivina lævis*, L.**

*Ovary* of one carpel, one-celled, one-ovuled; ovule basal, erect, amphitropous; micropyle inferior or pointing to the base of the seed close to the hilum.

*Fruit* baccate, subglobose, laterally compressed, tipped by the persistent style, glabrous, scarlet, one-seeded.

*Seed* vertical, laterally compressed, deep brown or black, densely pubescent; hilum small, basal, slightly depressed, with the depression almost filled with a small, colourless, bilobed, funicular aril.

*Endosperm* copious, white, farinaceous, lying inside the embryo, or between that and the hilum.

*Embryo* curved round the whole periphery of the seed except a small part close to the hilum, fleshy, soft, colourless; cotyledons

longitudinally convolute, forming a thick cylinder, and when vertically cut giving the appearance of four cotyledons ; radicle cylindrical, bluntly pointed, somewhat longer than the cotyledons, with its apex near the hilum.

**Seedling (fig. 615).**

*Primary root* nearly vertical, light red, with numerous slender, branched, lateral rootlets.

*Hypocotyl* herbaceous, about 2 cm. long, 1 mm. thick, terete, glabrous, brown.

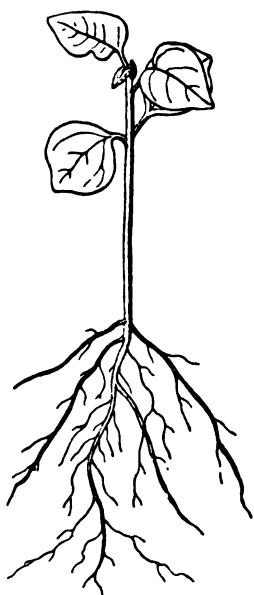


FIG. 615.—*Rivina levis*.  
Nat. size.

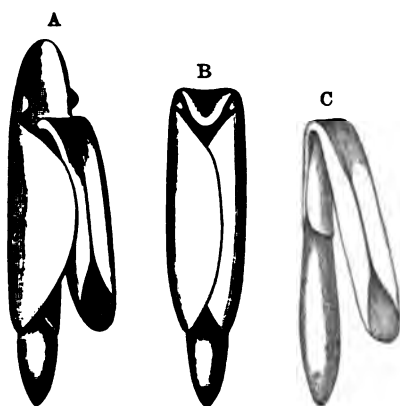


FIG. 616.—*Petiveria octandra*. Embryo and cotyledons,  $\times 6$ . A, embryo partly unfolded. B, outer and shorter cotyledon. C, inner and longer cotyledon.

*Cotyledons* not quite opposite, petiolate, unequal, about 1.5 cm. long, a little over 1 cm. wide, broadly cordate or suborbicular, shortly and obtusely cuspidate, trinerved, thin, glabrous, bright green, not very persistent ; petioles slightly channelled, red, glandular.

*Stem* like the hypocotyl ; bases of leaves decurrent.

*Leaves* simple, entire, cauline, alternate, exstipulate, petiolate, alternately incurvinerved, glabrous, subreticulate, membranous, deep green above, paler beneath.

Nos. 1 and 2. Cordate, acute, incurvinerved.

***Petiveria octandra*, L. (fig. 616).**

*Ovary* of two carpels, one-celled, one-ovuled ; ovule basal, erect, amphitropous ; micropyle inferior.

*Fruit* an achene, oblong-linear, subcuneate, laterally compressed and surrounded longitudinally with a median ridge on both sides, longitudinally striated and sulcate, bifid at the apex and crowned with two to six unequal-sized, closely reflexed acute bristles, more or less hairy, brown ; pericarp coriaceous, closely adhering to the seed.

*Seed* oblong-linear, conforming to the interior of the achene ; testa membranous ; tegmen adhering to the endosperm ; hilum basal, somewhat oblique ; micropyle contiguous to the hilum ; raphe none.

*Endosperm* moderately copious, whitish, subfarinaceous or fleshy.

*Embryo* large, surrounded by the endosperm, doubled upon itself ; cotyledons very unequal, and often only one, the smaller being aborted ; larger one very broad, deeply cordate at the base, strongly convolute and enclosing the smaller when present ; apex subtrilobate, with rounded obtuse lobes, the lateral ones curving round the smaller cotyledon, while the middle one is curved at the apex and just within the endosperm at the apex of the seed ; inner one much longer, convolute within the larger one, refracted near the middle, just within the apex of the endosperm and carried down again nearly to the tip of the radicle ; radicle stout, cylindrical, obtuse, rather long, close to the micropyle at the base of the seed.

**Seedling (fig. 617).**

*Primary root* slender, with many colourless branched fibrous rootlets.

*Hypocotyl* herbaceous, about 2 cm. long, 1 mm. thick, slightly ridged, pubescent, green or brownish-red.

*Cotyledons* very unequal, stalked, generally one is about 2 cm. long, 1.75 cm. wide, subcordate, obtusely cuspidate, coarsely crenate, sinuate near the apex, trinerved at the base, penninerved. The other is about 3 cm. long, 1.25 cm. wide, oblong, obtuse at both ends, entire, penninerved ; both are glabrous except the short pubescent petioles, thin, with sunk midrib, bright green, not very persistent.

*Stem* herbaceous, erect ; 1st internode 6 mm. long, 1-1.5 mm. thick, terete, pubescent, brown.

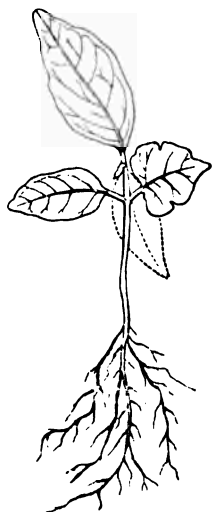


FIG. 617.  
*Petiveria octandra*.  
Half nat. size.

*Leaves* simple, entire, cauline, alternate, stipulate, petiolate, alternately incurvinerved, glabrous or somewhat pubescent, membranous, smelling strongly of garlic ; stipules small.

Nos. 1-8. Very much like the entire cotyledon, only larger, 4-5 cm. long, nearly 2 cm. wide ; apex oblique ; margin sinuate.

***Phytolacca pruinosa*, Fenzl.**

*Pistil* apocarpous or very nearly so, of six to eight carpels, each one-celled, one-ovuled ; ovules erect, campylotropous ; micropyle inferior.

*Fruit* baccate, of six to eight juicy carpels arranged in a whorl, slightly united by their bases laterally but not in the centre, glabrous, deep black, shining.

*Seed* reniform, vertical, somewhat compressed laterally, with a hard, crustaceous, deep black and shining testa, glabrous, unequal at the base—the smaller auricle containing the radicle, the larger the cotyledons ; hilum basal in the notch ; micropyle close to it.

*Endosperm* central, floury, loose, white.

*Embryo* much curved, peripheral, not so white as the endosperm which it encloses, comparatively large ; cotyledons linear, obtuse, semiterete, plano-convex, placed with their backs to the axis, and their edges to the compressed sides of the seed ; radicle cylindrical, obtusely pointed, about half as long as the cotyledons.

***Phytolacca acinosa*, Roxb.**

*Fruit* of six to eight one-seeded, baccate, drupe-like carpels.

*Seed* oblong, 3-4 mm. long, laterally compressed ; testa smooth, shining, black, crustaceous ; hilum rather conspicuous.

*Endosperm* rather copious, white, farinaceous, surrounded by the embryo.

*Embryo* curved, lying round the endosperm, colourless ; cotyledons linear, obtuse, entire, closely adpressed, lying the narrow way of the seed, with their faces to the axis ; radicle terete, obtuse, incumbent, shorter than the cotyledons.

***Phytolacca abyssinica*, Hoffm. (fig. 618).**

*Hypocotyl* 1-2 cm. long, 2 or 3 mm. thick, terete, glabrous, reddish, succulent.

*Cotyledons* shortly stalked, nearly equal, 3-5 cm. long, 1.5-2 cm. wide, lanceolate-ovate, acute and produced at the base, subacute at the apex, entire, with sunk midrib, obscurely penninerved, glabrous, fleshy but not thick, yellowish-green ; petiole 1 cm. long, 2-3 mm. wide, stout, channelled.



*Stem* terete, succulent, edges of petiole decurrent, glabrous, purplish-brown; internodes about 1 cm. long, as thick as the hypocotyl.

*Leaves* simple, entire, cauline, alternate (first two opposite), exstipulate, petiolate, alternately incurvinerved, glabrous, subfleshy; petiole grooved on the upper side.

Nos. 1 and 2. 5-7 cm. long, 2.5-3 cm. wide, with stout, channelled, reddish petioles 1 cm. long, 2.5 mm. wide, and an ovate-elliptic, acute, entire, mucronate blade.



FIG. 618.  
*Phytolacca abyssinica*.  
Half nat. size.

## POLYGONACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 88.

*Fruit and Seed.*—The ovary is superior, rarely slightly sunk in the receptacle, syncarpous, and consists of two to three, rarely four carpels, trigonous, or compressed, rarely tetragonal, one-celled, with a basal, erect, orthotropous ovule; the ovule is sessile or erect on the apex of a funicle, sometimes pendulous from the recurved apex of an elongated basal funicle. The fruit is nutlike, trigonous, compressed or rarely tetragonal, and indehiscent, clothed by the unchanged or accrescent perianth, rarely exserted from it. The pericarp is crustaceous, rarely leathery or hardened. The seed is sessile, erect and orthotropous, rarely stipitate, and conforms to the interior of the fruit; sometimes it is longitudinally furrowed and three- to six-lobed. The testa is membranous and filled with copious farinaceous endosperm, rarely is the endosperm subfleshy and scanty. The embryo is often more or less excentric or lateral, variously curved or straight, sometimes peripheral. The cotyledons are flat, narrow or wide, rarely very wide and convolute. The radicle varies considerably in length and is superior or ascending.

The pistil is tetramerous in *Calligonum*. The ovule is suspended from a recurved funicle in *Leptogonum*, *Brunnichia*, and *Antigonon*. The perianth completely encloses the fruit, or is solid in *Oxygonum*, *Emex*, and *Symmeria*, fleshy or

baccate in *Muehlenbeckia*, *Coccoloba*, and in a few species of *Polygonum*. It is adnate to the nut in several species of *Coccoloba*.

Reckoned according to the form and position of the embryo, three different types of seeds have come under my observation. In all cases the seed itself is trigonous, and conforms to the interior of the fruit. The simplest form is represented by *Rumex obtusifolius*. The embryo is straight or slightly curved in conformity with the outline of the seed, as it is excentric and lies along one of the three faces outside the endosperm. The cotyledons are oblong, plano-convex, and somewhat longer than the terete radicle. The fruit and seed of *R. Patientia* are more decidedly narrowed to the base and ellipsoid; the embryo is excentric, as long as the seed, and therefore much curved in conformity with it. The cotyledons are linear, plano-convex, narrow, and longer than the terete radicle.

The embryo of *Rheum palmatum* (fig. 621) is relatively larger and generally slightly excentric, with broadly oblong cotyledons, abruptly narrowed into the radicle which is short, terete, and lies in the narrow neck of the seed quite uncovered by endosperm. The cotyledons are flat or more or less folded longitudinally, and exceptional cases occur where one is oblique to the other, and in one instance they were twisted at right angles to one another so as to occupy the three angles of the seed and thus attain the greatest possible size. The fruit is broadly three-winged, and the inner wall is greatly but unequally thickened, suberous, and so indents the testa and endosperm in places as to make the latter appear ruminated.

The seed of *R. officinale* is not abruptly narrowed at the apex so that the radicle remains embedded in endosperm. The embryo as a whole is nearly if not quite central, with narrowly oblong cotyledons slightly longer than the radicle, and is relatively smaller than that of *R. palmatum*.

The seed of *Fagopyrum esculentum* (fig. 619) is large, ovoid-trigonous, rarely with the angles nearly obliterated and rounded. The embryo is relatively very large, variously folded and convolute longitudinally, similar to what occurs in *Geranium*, except that endosperm is here present and is nearly divided in

half by the cotyledons. In transverse section the latter are seen to be twisted in the form of the letter S, with endosperm occupying the sinus. They are deeply but unequally auricled at the base, and the two halves of the lamina are unequal, and the whole therefore unsymmetrical for the same reason as in *Geranium*. The larger halves are outermost and hug the testa, closely following two out of the three angles of the seed and enclosing the smaller halves. The latter retain their smaller size after germination. The radicle is large, fusiform, and completely enclosed by the folds of the cotyledons.

The cause of the inequality in the two halves and of the auricles of the cotyledons is as follows:—

The embryo in the young state becoming too wide for the interior of the seed, becomes first folded together longitudinally, and growth continuing the cotyledons become spirally convolute, forming a large open spiral with all the intermediate spaces filled with the white floury endosperm. The cotyledons at length get outside the endosperm and direct their course into two out of the three angles of the seed, thus obtaining the greatest possible width. Looking from the apex of the seed—that is, from the radicular end of the embryo to the lower end of the seed—the cotyledons are after the first folding both twisted in the same direction, from right to left, or in the opposite direction to the course of the sun, or this direction may be reversed. In consequence of this one half of each cotyledon is enclosed by the corresponding half of the other, so that the outer half of each has more room to develop, and is both larger and has larger auricles.

*Seedlings*.—The cotyledons vary greatly in size and shape, sometimes even in the same genus. Those of *Pterostegia drymarioides* are rotund, obtuse, entire, and petiolate with a lamina 6·5–7·5 mm. long and the same in width. In the case of *Polygonum sphærostachyum* they are rotund, trinerved, and taper slightly at the base into short petioles, connate at the base, forming a cup round the axis. The cotyledons of *Rumex Bucephalophorus* are narrowly ovate-oblong; and the two primary leaves are oval. The cotyledons of a species of Himalayan *Rheum* from the Saharanpur gardens (N.W. India) are large, foliaceous, ovate-oblong, and

obtuse. The cotyledons of *Rheum officinale* (fig. 622) are broadly ovate, obtuse, obscurely three- to five-nerved, and have their petioles slightly connate at the base. The hypocotyl is undeveloped or indistinguishable from the root, which becomes thick and fleshy at an early stage. The first leaf is ovate-oblong, subcordate at the base. The ultimate leaf is cordate-palmate, five-nerved and -lobed, and lobulate or coarsely dentate between the lobes.

A very distinct type is met with in *Coccoloba uvifera* (fig. 623) which has cotyledons similar to those of *Coffea*. They are large, foliaceous, oblate or subquadrate, five-nerved from the base, strongly reticulate, and truncate at the apex or widely, shallowly and erosely emarginate.

The large and foliaceous cotyledons of *Fagopyrum* are also very distinct. They are more or less unsymmetrical with unequal basal auricles as explained above. Those of *F. emarginatum* are rhomboid-orbicular, unsymmetrical, five-nerved at the base and penninerved upwards. The first leaf is cordate-hastate, and the second similar but more acuminate, with ochreate stipules as in other members of the Order. The cotyledons of *F. tataricum* (fig. 620) are suborbicular, rounded at the apex, and very unequally auricled at the base with the larger auricle of one on the opposite side from that of the other as it was developed in the seed. The venation is similar to that of the last species.

***Pterostegia drymarioides*, Fisch. et Mey.**

*Primary root* slender, flexuose, finely branched.

*Hypocotyl* short, subterranean and scarcely distinguishable from the root, red.

*Cotyledons* rotund, obtuse, entire, petiolate, glabrous; lamina 6.5–7.5 mm. long, and about the same in width; petiole slender, slightly furrowed on the upper surface, 9–11 mm. long.

*Stem* herbaceous, dichotomously branched; 1st internode undeveloped; 2nd 5–9 mm. long.

*Leaves* simple, radical and cauline, opposite, unequal, stipulate, petiolate, very thinly pubescent or almost glabrous; petiole slender, slightly channelled above. Inequality of leaves; lamina 6.5–7.5 mm. long and 1–1.8 cm. wide; petioles 1.7–2 cm.

*Stipules* represented by a slender connecting rim between the petioles or by their slightly connate bases.

First to third pairs oblate, emarginate or bifid, like the cotyledon of a *Convolvulus* or *Brassica*, giving off a few leading nerves into the side lobes.

***Polygonum sphærostachyum*, Meisn.**

*Primary root* normal.

*Hypocotyl* very short and unapparent.

*Cotyledons* entire, almost orbicular, about 4 mm. in diameter, glabrous, trinerved, with long petioles from 1.5–2 cm., which joining at the base of the leaf form a hollow tube through which the real leaves pass, giving the appearance of an erect hypocotyl with sessile cotyledons.

*Stem* at first very short, so that the leaves appear radical.

*First leaves* radical, obtusely lanceolate, alternate, simple, entire, light green with long petioles from 2.5–8 cm.; midrib with numerous lateral veinlets.

***Fagopyrum esculentum*, Moench. (fig. 619).**

*Fruit* an achene, acutely or obtusely trigonous or sub-three-winged, crustaceous, brown, sometimes with black transverse stripes, or entirely black, glabrous, much longer than the persistent withered perianth, slightly narrowed to the base, but more to the apex.

*Seed* large, ovoid-trigonous, filling the cavity of the ovary and conforming to it in shape; testa very pale brown or straw-coloured, glabrous, shining; hilum basal; chalaza rather large, conspicuous, orbicular, reddish-brown, basal; micropyle apical.

*Endosperm* copious, dry and floury, white.

*Embryo* very large, lying in the centre of the endosperm and variously stretched from one angle of the seed to another, and equal in length to the seed, straight; cotyledons very wide, variously twisted about or plaited, often striking into two out of the three angles of the seed, and these following the interior of the testa for some distance, apparently outside the endosperm, very shortly petiolate; radicle rather large, subfusiform, tapering to an obtuse point, completely hidden by the folds of the cotyledons.

**Seedling.**

*Hypocotyl* 6–12 cm. long, 1.5–2.5 mm. thick, succulent, terete, glabrous, red.

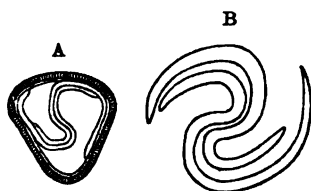


FIG. 619.—*Fagopyrum esculentum*.  
A, transverse section of seed,  $\times 4$ .  
B, embryo,  $\times 8$ .

*Cotyledons* nearly equal, obtuse, rhomboid-orbicular, oblique, entire, penninerved, plane, glabrous, thin but fleshy, pale green, 1-2 cm. long, and 2-3.5 cm. wide; petioles channelled, glabrous, succulent, reddish, connate at the base, 1.5-2 cm. long, about 1 mm. thick.

*Stem* succulent, terete, glabrous, reddish; 1st internode 3-7 cm. long, 1.25-2 mm. thick; 2nd shorter and thinner.

*Leaves* rather membranous, three- to five-nerved at the base, and penninerved upwards.

No. 1. 3-5 cm. long, 2-4.5 cm. wide, cordate-hastate, obtusely acuminate, entire, palmatinerved, thin, with mealy pubescence, light green; petiole channelled above, glabrous or slightly pubescent.

No. 2. Similar but more acuminate.

*Fagopyrum tataricum*, Gaertn. (fig. 620).

*Primary root* long, tapering downwards, colourless, giving off short, slender, lateral fibres.

*Hypocotyl* erect, terete, minutely glandular-pubescent, red, striated with darker lines, shining, 2-2.8 cm. above the soil and tapering insensibly into the root.

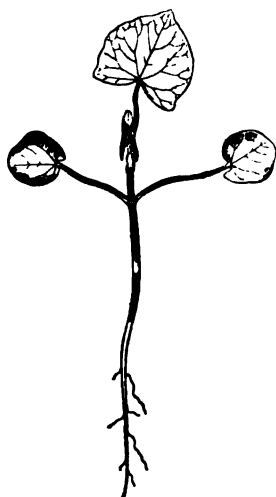


FIG. 620.  
*Fagopyrum tataricum*.  
Half nat. size.

*Cotyledons* suborbicular, rounded at the apex, cordate at the base and unequally auricled, the longer auricle of one cotyledon on the opposite side to that of the other, while the lamina is generally larger on the side with the longer auricle, faintly five-nerved at the base, petiolate, deep subglaucous-green above, paler beneath, glaucous and slightly reticulate; lamina 1.3-1.5 cm. long, including the auricles, 1.2-1.4 cm. wide; short side of a typical, good-sized cotyledon 1.1 cm. long, 5.75 mm. wide; longer side 1.4 cm. long, 8.5 mm. wide; petioles semiterete, channelled above, glabrous, shining, dilated and connate at the base forming a cup round the plumule,

tapering upwards and becoming rather slender, unequal in length; longer one in specimen described 2.7 cm. long; shorter one 2.15 cm.

*Stem* erect, terete or somewhat flattened on two sides, thinly pubescent on the internodes and more densely so at the nodes or

papillose, pale green closely striated with red lines; 1st internode 6-9 mm. long.

*Leaves* simple, cauline, alternate, stipulate, petiolate, five-nerved at the base and alternately nerved upwards, with branching anastomosing veins, deep glaucous-green above, paler and glaucous beneath, glabrous; petioles semiterete, channelled on the upper side, tapering upwards from a stout base, pale green, pubescent or papillose at the margins on the upper side, shining; stipules connate by their edges and forming a sheath around the stem to which their bases are adnate, thin and membranous for the greater part, entire or lacerated at their free upper edges, glandular-pubescent or papillose, pale green or almost colourless.

No. 1. Reniform-triangular, subhastate, cuspidate, acute, five-nerved at the base, alternately nerved upwards, and reticulate.

*Rheum palmatum*, *L.* (fig. 621).

*Ovary* one-celled, one-ovuled; ovule basal, erect, orthotropous; micropyle superior.

*Fruit* an achene, surrounded at the very base with the persistent

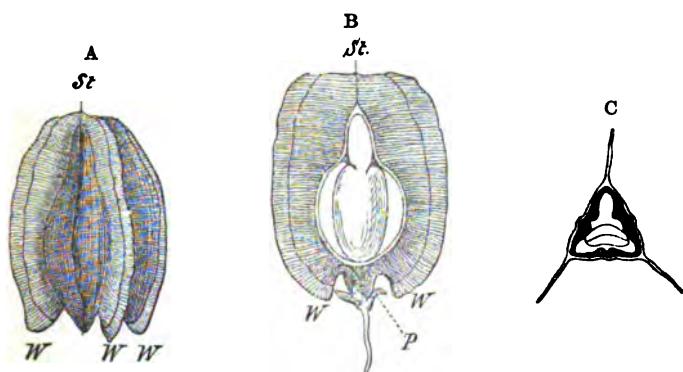


FIG. 621.—*Rheum palmatum*.—A, achene,  $\times 3$ : *St*, style; *W*, *W*, *W*, wings. B, longitudinal section of achene,  $\times 3$ : *St*, style; *W*, *W*, wings; *P*, perianth. C, transverse section of achene,  $\times 8$ .

remains of the perianth, ovoid-triangular, broadly and thinly three-winged, suddenly tapering to a cuneate base, tipped with the base of the styles, dark brown, glabrous; wings traversed longitudinally with a nerve running nearer the margin than the attachment, reticulate, pale brown.

*Seed* trigonous, conical or flask-shaped, suddenly narrowed at the base, gradually narrowed to the apex, conforming in shape to the fruit except the wings, raised into a more or less prominent ridge

on each of its three faces ; testa thin, red, more or less adhering to the suberous endocarp ; hilum and chalaza basal and inconspicuous.

*Endosperm* copious, floury, white when dry but yellow when moist, surrounding the embryo except the radicle and sometimes the edges of the cotyledons, appearing somewhat ruminated in transverse section owing to the unequal thickening of the corky endocarp.

*Embryo* straight, large, generally slightly excentric, colourless ; cotyledons oblong, obtuse, entire, abruptly narrowed into the radicle, lying near one side of the triangle in the transverse section of the seed, and flat or slightly bent or doubled upon themselves longitudinally ; radicle short, stout, narrowed to an obtuse point and lying in the apex of the seed uncovered by the endosperm.

Exceptions to the position of the cotyledons occur where one is oblique to the other, often lying against the sides of the seed from the absorption of the endosperm at their edges. A case occurred where one cotyledon was twisted at right angles to the other, so as to occupy the three angles of the seed.

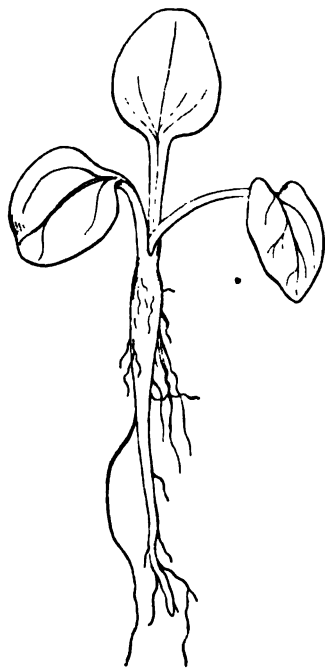


FIG. 622.—*Rheum officinale*.  
Nat. size.

*Rheum officinale*, Baill. (fig. 622).

*Primary root* stout, fleshy, tapering downwards, with lateral fibres, brownish.

*Hypocotyl* very short, fleshy, brownish, hardly distinguishable from the root, about 6 mm. long.

*Cotyledons* broadly ovate, obtuse, three- or obscurely five-nerved, entire, scabrous at the margin, glabrous, fleshy, light opaque green ; lamina 1.65 cm. long, 1.4 cm. wide ; petioles flattened above, convex on the back, pale green or suffused with red, glabrous, connate at the base forming a sheath for the plumule, 1.75 cm. long including the sheath.

*Stem* herbaceous, forming a short, persistent, fleshy rootstock, with large, fleshy, tuberous or tuber-like roots, elongating when about to flower.



*Leaves* simple, radical and cauline, alternate, stipulate, petiolate, alternately penninerved in the young state and entire, but palmately five-nerved in the adult plant, glabrous in the seedling, but afterwards pubescent beneath; petiole semiterete, flattened above with obtuse edges, pale green, often stained with red, glabrous in seedling but pubescent in the adult; stipules none on the first leaf, or hidden in the sheath.

No. 1. Ovate-oblong, obtuse, subcordate at the base, somewhat scabrous at the margin.

*Coccoloba uvifera*, Jacq. (fig. 623).

*Hypocotyl* erect, terete, glabrous, rather stout and of about equal thickness all the way up, 4–6·8 cm. above the soil, pale green stained with red.

*Cotyledons* large, foliaceous, oblate or quadrangular, erosely truncate at the apex, or widely, shallowly and irregularly emarginate, shortly petiolate, coriaceous, bright green and shining above, paler beneath, trinerved from the base with the midrib again forked about the middle, making in all four principal nerves, the outer one of each pair incurving, the inner curving outwards, each pair meeting above; from these smaller ones are given off and anastomose throughout the lamina, which is 2·4–2·65 cm. long and 8–8·4 cm. wide; petiole flattened above or slightly grooved, convex on the back, minutely puberulous at the margin, connate at the base or produced into a stipuliform or ochreate sheath enveloping the plumule, 2·5 mm. long, with the sheath about 1·5 mm. long.

*Stem* erect, terete, minutely puberulous, ultimately woody; 1st internode 1·8–1·4 cm. long; 2nd short, about 2–8 mm.

*Leaves* simple, cauline, alternate, stipulate, shortly petiolate, alternately incurvinerved, with the nerves uniting at their curved tips, reticulate, coriaceous, glabrous except the petiole, a deep shining

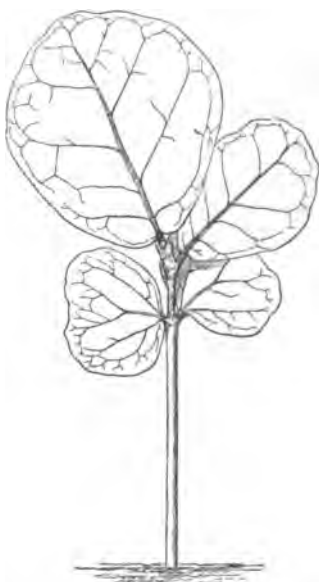


FIG. 623.—*Coccoloba uvifera*.  
Half nat. size.

green above, or in the young state more or less stained with red ; stipules ochreate, forming a sheath round the stem, and in their youngest state a cap to the terminal bud, and after loosing the cap becoming truncate.

Petioles very short, semiterete, grooved above, minutely puberulous at the margins.

No. 1. Obovate, broad and obtuse at the apex, very shallowly sinuate or nearly entire, slightly cordate at the base.

No. 2. Rotund, obovate, much larger, broad and obtuse at the apex, obsoletely angled or almost entire at the margin, cordate at the base, with short rounded auricles.

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## ARISTOLOCHIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 121.

*Fruit and Seed.*—The ovary is inferior or rarely half-superior, consisting of four to six carpels cohering by their edges, with the placentas projecting into the cavity and making it imperfectly four- to six-celled, or cohering and forming as many complete cells. The ovules are indefinite in each cell, usually very numerous, horizontal or pendulous, superposed in one or two series and anatropous. The fruit is sometimes indehiscent, crowned with the persistent perianth, and liberating the seeds only by decay, or it is capsular with a deciduous perianth, dehiscing septicidally or breaking away from the placentas. The seeds are indefinite, often very numerous, horizontal or pendulous, immersed in a spongy cellular tissue arising from the endocarp, ovoid or oblong, obtusely trigonous, or compressed and flat or concave. The testa is crustaceous, rugose or smooth, with the raphe in plano-concave seeds fleshy and thickened or dilated. Endosperm is copious and fleshy. The embryo is minute, enclosed in the endosperm close to the hilum, oblong or ovoid, with the cotyledons closely applied to one another and about as long as the radicle.

*Seedlings.*—The cotyledons attain a comparatively large size during germination by feeding upon the endosperm. Those of *Aristolochia caudata* are broadly oblong, rounded and entire at either end, five-nerved at the base and strongly

nerved upwards with alternate branching nerves. The lamina hangs perpendicularly from the apex of its horizontal petiole. The whole seedling of *Aristolochia elegans* (fig. 624) is smaller. The cotyledons are broadly oval, obtuse, emarginate, suddenly narrowed into the petiole, trinerved throughout their length and reticulate. The first pair of leaves are smaller than the cotyledons, for which they might be mistaken as they are nearly on the same level, suborbicular and emarginate, but they are trinerved at the base only with alternate nerves upwards. The following three leaves are broadly reniform and trinerved with copiously branching nerves.

***Aristolochia caudata*, L.**

*Root* short, oblique, slightly branching.

*Hypocotyl* about 6 cm. long, 2 mm. thick, terete, glabrous, herbaceous, green.

*Cotyledons* with shallow channelled, glabrous, horizontal petioles and vertically reclinate or pendent blade 2·5 cm. long, 2 cm. wide, oblong, rounded, entire, penninerved, glabrous, thin, deep glaucous-green above, paler beneath.

*Stem*.—1st internode 2 mm. long and as thick; 2nd twice as long, but thinner than the first, terete, slightly pubescent, green.

*Leaves* simple, cordate at the base, otherwise entire, cauline, alternate (the first two opposite), exstipulate, petiolate, glabrous, glaucous-green above, paler beneath; petiole somewhat pubescent.

Nos. 1 and 2. Opposite, long petioled, reclinate, with a blade 3 cm. long, 2·5 cm. wide, subcordate, acute, subpalmatinerved, reticulate, entire, quite glabrous, deep glaucous-green above; petiole 3 cm. long, 1·5 mm. wide, slightly pubescent.

Nos. 3, 4, &c. Alternate, broadly cordate through the appearance of a small veinlet and accompanying parenchyma at the base of the lowest vein of each of the two basal primary nerves.

***Aristolochia elegans*, Masters (fig. 624).**

*Hypocotyl* erect, terete, slender, glabrous, 8–10 mm. above the soil.

*Cotyledons* broadly oval, obtuse, minutely emarginate, suddenly tapering into the petiole, foliaceous, membranous, glabrous, trinerved

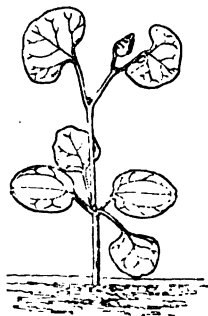


FIG. 624.  
*Aristolochia elegans*.  
Nat. size.

with the lateral ones giving off short branches on their outer sides ; lamina 8-9 mm. long, 6.5 mm. wide ; petiole slender, channelled above, 2.5 mm. long.

*Stem* erect, terete, slender, glabrous, ultimately climbing ; 1st internode undeveloped ; 2nd 1.2-1.3 cm. long.

*Leaves* simple, cauline, alternate except the first pair, entire, glabrous, petiolate, exstipulate ; petiole slender, subterete, channelled above.

Nos. 1 and 2. Opposite, suborbicular, minutely emarginate, rather truncate at the base, petiolate, much smaller than the cotyledons and resembling them, but having more the venation of a foliage leaf.

Nos. 3-5. Reniform or broadly reniform, entire, trinerved, with all three nerves branching rather copiously, reticulate, glabrous.

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## PIPERACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 125.

*Fruit and Seed.*—The ovary is superior, sessile or rarely stipitate, consisting of three to four many-ovuled carpels, distinct or united at the base, or is one-celled and one-ovuled. The ovule is solitary and erect, or there are several ascending and orthotropous. The fruit is small and capsular in genera having numerous carpels, or it breaks up into three to four cocci or follicles ; in genera where it is one-ovuled it is baccate and indehiscent, with a succulent or thin and almost dry pericarp. The seed or seeds according to the number present are globose, ovoid or oblong. The testa is membranous or thinly fleshy, rarely coriaceous. Both perisperm and endosperm are present and farinaceous. The former is copious and occupies the greater part of the seed, is often snowy-white and in many cases hardened at the periphery. The endosperm forms a small mass embedded in the perisperm close to the superior micropyle, distant from the hilum, and encloses the minute embryo. The cotyledons are short, often not very distinct ; and the radicle is superior. A few exceptional cases occur as in *Saururus* and *Lactoris* where the fruit breaks up into cocci. The fruit is one-celled and opens at the top in

*Houttuynia*. In the genus *Lactoris*, where perisperm is comparatively scanty, it is oily rather than farinaceous.

*Seedlings*.—The embryo is very small while in the seed, but attains a relatively large size during germination, and the cotyledons assume somewhat the form of the seed. In *Piper celtidifolium* (fig. 625) they are broadly triangular, cuspidate, truncate at the base or inclined to cordate, membranous, and faintly trinerved. The first leaf is cordate and five-nerved, with strong sheaths at the base of the petiole. The next two are more elongated and more deeply auricled at the base, but otherwise similar. The hypocotyl of *Peperomia fernandeziana* is short and fleshy. The cotyledons are ovate, cuspidate and fleshy with no apparent venation. The stem is also fleshy. The first two leaves are oval or sometimes obovate, followed by three which are oblong and gradually larger.

*Piper celtidifolium*, *Hamilt.* (fig. 625).

*Hypocotyl* erect, terete, glabrous, 5–8 mm. long.

*Cotyledons* broadly triangular, obtusely cuspidate, petiolate, rather indistinctly trinerved, and reticulate, membranous, glabrous, truncate at the base or faintly inclined to be cordate, 8.5–9.5 mm. long, 9.5–10.5 mm. wide; petiole slightly channelled above, 4 mm. long.

*Stem* erect, terete, somewhat zigzag from node to node, glabrous, somewhat striate; 1st internode undeveloped; 2nd 6.5 mm. long.

*Leaves* simple, entire, cauline, alternate, exstipulate, petiolate, three- to five-nerved from the base, and reticulate, glabrous; petioles channelled above, sheathing the stem at the base, glabrous.

No. 1. Cordate, obtuse, entire.

Nos. 2 and 3. More elongated and more deeply auricled at the base.

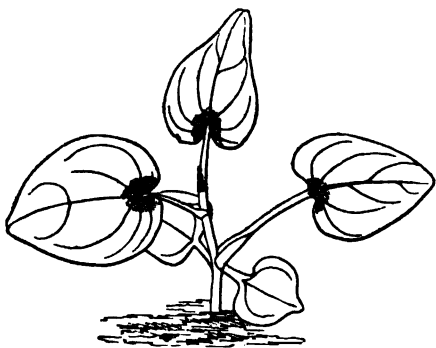


FIG. 625.—*Piper celtidifolium*. Nat. size.

***Peperomia fernandeziana*, Miq.**

*Hypocotyl* short, fleshy, tapering downwards, glabrous, marbled with red on a pale green ground, 3–6 mm. long.

*Cotyledons* ovate, cuspidate, subacute, petiolate, glabrous, fleshy, without apparent venation, pale green; lamina 4 mm. long, 3 mm. wide; petiole 1–1·25 mm. long.

*Stem* somewhat fleshy, erect, terete, red, thinly hairy with woolly hairs; 1st internode 2–3·5 mm. long, or sometimes scarcely developed; 2nd 1–7·5 mm. according to the strength of the plant.

*Leaves* simple, entire, cauline, alternate, sometimes opposite, exstipulate, petiolate, glabrous, fleshy, opaque above with the three nerves scarcely discernible, silvery white beneath and distinctly trinerved; petioles shallowly channelled above, thinly woolly, hairy, narrowed to their insertion at the base.

Nos. 1 and 2. Oval, obtuse, or sometimes subobovate.

Nos. 3–5. Oblong, obtuse, gradually larger.

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**PROTEACEÆ.**

Benth. et Hook. *Gen. Pl.* iii. 165.

*Fruit and Seed*.—The ovary is superior, apocarpous, one-celled, oblique or excentric, with one, two, or several ovules. The ovules are collateral when geminate, rarely almost superposed, or numerous and superposed in two series, sometimes inserted on or close to the apex, and superposed, sometimes laterally affixed, amphitropous, or almost anatropous, ascending from the base or descending, with the micropyle always inferior. The fruit is nutlike or drupaceous, and indehiscent, sometimes dehiscing at last along the inner margin or at the apex, like a follicle or capsule. The seeds are solitary, twin or few, flattened, compressed or thickened. The testa is membranous or coriaceous, and often winged in a variety of ways. Endosperm is wanting. The embryo conforms in shape to the seed excepting the wing when that is present. The cotyledons are sometimes much flattened and equal, sometimes much thickened and unequal. The radicle is short, straight, and inferior or lateral, and often enclosed between the auricles of the cotyledons.

The Order is divided into two series according as the fruit is nut- or drupe-like and indehiscent ; or dehiscent and capsular or follicular ; but in the latter group there are some exceptions. The dry woody fruits may hang on the plants for years before bursting open.

The fruit of *Grevillea Hilliana* is a woody, one- to two-seeded follicle, dehiscing by the separation of the two carpels. The seed (fig. 628) is oblate, or oval, laterally much compressed, winged all round and attached to the placenta by one edge. The chalaza is at the upper end of the portion containing the embryo, and the raphe pursues a circuitous course over the wing, and then recurves towards the hilum below the middle of one edge of the seed. The embryo occupies the whole of the interior, and has broadly obovate cotyledons tapering to the base where they are strongly auricled in order to accommodate the short radicle.

The fruit of *Hakea acicularis* is broadly ovoid, thick-walled and very woody, but dehisces by two valves when mature and dry. When two seeds are produced in a fruit, they are semi-obovoid by mutual pressure, gibbous on one side, and flat or slightly concave on the faces in contact. The testa is tuberculated and black, and is produced into a brown or black, membranous and perforated wing, along one side and round the apex of the seed. The wing is obliquely oblong-ovate, about 1.5 cm. long, and 1 cm. wide. The cotyledons are obovate, deeply auricled at the base, rather unequal in thickness owing to mutual pressure and the peculiar form of the seed.

*Seedlings*.—There is great variation among the cotyledons, due chiefly to the size and shape of the seed in which they are formed, and that again owes its shape to the cavity of the fruit and whether one or two seeds are present. A large number of them have cotyledons varying between roundly obovate and oblong-obovate, auricled at the base, sessile or subsessile, indented on one side or having a sinus which gives them a falcate appearance. The roundly obovate form is well represented by *Hakea acicularis* (fig. 631). The presence of the auricles is explained in the account of the seeds of *Grevillea Hilliana*. The leaves of *Hakea acicularis* are narrowly linear

and acute; the first four are very short, and all are very much narrower than the cotyledons. In *H. laurina* the cotyledons are obovate and considerably smaller than those of the last.

The cotyledons of *H. eucalyptoides* are oblong-obovate and sometimes indented on the sides. The first five leaves are lanceolate, the two primary ones being opposite. The cotyledons of *H. florida* are obovate-oblong and subfalcate owing to the indentation on one side. The cotyledons of *Grevillea Hilliana* (fig. 629) are obovate, trinerved, much larger than those of *Hakea laurina*, but otherwise similar. In weak seedlings the second and third leaves are spatulate and trifid; but in strong seedlings the next three at least are cuneate, gradually tapering to a petiole-like base and more deeply trifid. The cotyledons of *Stenocarpus salignus* are oblong-obovate, trinerved, and differ slightly from the type in having shorter basal auricles which clasp the axis horizontally. The first leaf is elliptic and entire. *Lambertia formosa* (fig. 627) has obovate and emarginate as well as auricled cotyledons. The cotyledons of *Leucospermum conocarpum* (fig. 626) are also emarginate, but they are unsymmetrical especially towards the base. They are scarcely, if at all, auricled at the base, but a broad and short petiole-like piece forms a sort of ligule clasping the axis in the very early stages of the seedling. A third type occurs in *Banksia australis* (fig. 632) which has oblong obliquely emarginate cotyledons, drawn out at the base into narrow horizontal auricles.

The cotyledons of *Grevillea punicea* differ in being longer, sometimes obliquely emarginate, sessile and connate at the base or perfoliate. Those of *G. linearis* agree with the last except that they are entire.

A number of types occur in the Order which cannot be classified with any of the above. The cotyledons of *Hakea multilineata* var. *grammatophylla* are obovate, retuse or truncate at the apex, and auricled at the base.

The cotyledons of *Protea mellifera* are obovate, spatulate, entire, sessile, fleshy and not auricled at the base. The latter character is unusual in the Order. The cotyledons of a species of *Roupala* from Bogota are oblong-ovate, acute, trinerved at



the base, petioled and not auricled ; both the last characters are unusual as well as the acute apex.

The cotyledons of *Banksia speciosa* (fig. 639) are obovate-oblong, ascending, obliquely truncate and crenate at the apex, trinerved and auricled at the base with subulate auricles cohering with one another and causing the cotyledons to assume their ascending direction.

***Protea mellifera*, Thbg.**

*Hypocotyl* stout, erect, terete, 3·5–4 cm. long, light green with a very slight reddish tinge.

*Cotyledons* thick, fleshy, obovate-spathulate, obtuse, entire, tapering to the base, but scarcely petiolate, glabrous, green, indistinctly one-nerved.

*Stem* erect, square, glabrous, herbaceous, ultimately woody ; 1st internode 3–4 mm. long ; 2nd 1–2 mm. ; 3rd and 4th 3–4 mm.

*First leaves* simple, entire, cauline, alternate, spathulate or almost lanceolate, acute, glabrous, petiolate with the petiole somewhat decurrent on the stem, or sessile, exstipulate, subglaucous, pinnatinerved.

***Leucospermum conocarpum*, R. Br. (fig. 626).**

*Hypocotyl* firm, nearly terete, 2–4 cm. long, 4 mm. thick, glabrous, brownish-green.

*Cotyledons* sessile, 1·5–2 cm. long, 1–1·25 cm. wide, 2–3 mm. thick, unequal, obliquely oblong, obtuse, emarginate, otherwise entire, uneven with a broadly raised obscure midrib, and a thick ligule-like collar near the base clasping the young stem before



FIG. 626.—*Leucospermum conocarpum*.  
Nat. size.

the unfolding of the cotyledons, glabrous, yellowish-green above, pale beneath.

*Stem* with very short internodes, terete, 2-3 mm. thick, shortly pubescent at the base, densely so towards the apex, not very firm, light green.

*Leaves* simple, entire or nearly so, cauline, alternate, exstipulate, sessile, coriaceous, densely hairy or villous, and excepting the midrib with an indistinct venation.

Primary ones sessile, 1-5 cm. long, 8-10 mm. wide, scattered; first few small or aborted, acute, linear, entire with sunk midrib, pubescent like the stem, bright green, with the lower ones horizontal, the others twisted forty-five degrees or more from the plane of the axis of leaf, which itself is at an angle of forty-five degrees to the main axis.

***Roupala* sp. (from Bogota).**

*Hypocotyl* erect, terete, glabrous, pale green, 7.5-10 mm. above the soil.

*Cotyledons* ovate-oblong, obtuse, or subacute, petiolate, with a few alternate, much ascending nerves, finely pubescent, light green above, paler beneath; lamina 1.2-1.85 cm. long, 4.5-5.5 mm. wide; petiole wide, grooved above, convex on the back, dilated and connate at the base, 2.5-3 mm. long.

*Stem* erect, flexuose, pale green, coarsely hairy or subvillous, ultimately woody; 1st internode 1.5-2.5 mm. long; 2nd 5-5.5 mm.; 3rd 6-7.5 mm.; 4th 8-8 mm.

*Leaves* in the seedling stage simple, cauline, alternate, exstipulate, sessile or shortly petiolate, alternately and ascendingly penninerved, hairy and scabrous on both surfaces, light green above, paler beneath, and somewhat shining, decurrent on the petiole when the latter is distinguishable; petiole when present short, deeply grooved or channelled above by the upturning of the edges, semi-amplexicaul, or often almost surrounding the stem.

No. 1. Obovate-cuneate, acutely serrate-dentate, with gland-tipped teeth, shortly petiolate.

No. 2. Similar, larger, wider, shortly petiolate.

No. 3. Similar, much larger, decurrent almost or quite to the base.

Nos. 4 and 5. Obovate-elliptic, much tapered to the base, irregularly and obtusely dentate or almost crenate, with the teeth tipped with an abruptly elongated gland or mucro.

**Lambertia formosa, Sm. (fig. 627).**

*Hypocotyl* erect, terete, pale green or red, glabrous, 9–15 mm. above the soil.

*Cotyledons* obovate and emarginate, or almost quadrangular, subsessile, shortly auricled at the base, thick, subrigid or coriaceous, glabrous, opaque, glaucous-green, ascending, more or less revolute longitudinally at the margin, 9–9·5 mm. long, 7–9 mm. wide, minutely and closely dotted with colourless spots.

*Stem* erect, terete, finely pubescent and hairy in the young state, scaberulous, pale green; 1st internode undeveloped or varying up to 4 mm. long; 2nd 4–7 mm.; 3rd 6·5–8·5 mm.; 4th 6–11 mm.

*Leaves* simple, entire, cauline, opposite or in whorls of three or four, decussate, exstipulate, sessile, finely reticulate on each side of a strong midrib, sunk on the upper and prominent on the under surface, even or undulate at the margin, and always slightly revolute there, horizontal, light green above, paler beneath, hairy when young and shortly and densely glandular-pubescent, glabrescent.

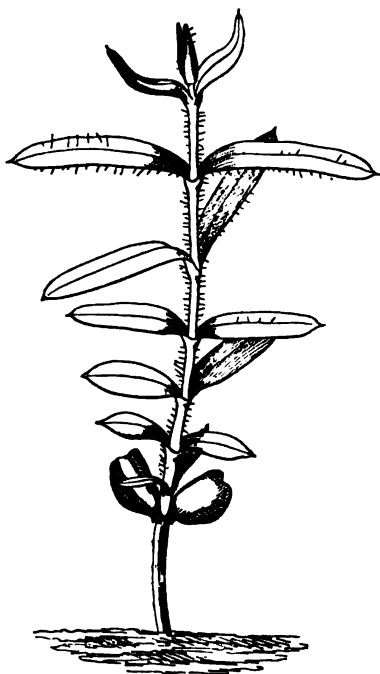


FIG. 627.—*Lambertia formosa*. Nat. size.

First and second pairs generally lanceolate, acute.

Third to ninth pairs linear-acute, cuspidate or bristle-tipped, slightly tapered to the base.

All these figures and descriptions are very liable to variation. Sometimes the third to seventh pairs are much shorter, wider, lanceolate and cuspidate.

The same numbers may be in whorls of three or four, or they may not be verticillate till the eighth or other higher nodes are reached.

*Grevillea Hilliana*, F. Muell. (fig. 628).

*Ovary* of one carpel, one-celled, with two laterally affixed amphitropous ovules.

*Fruit* a woody follicle, dehiscing when mature with two valves, one-celled, one- to two-seeded.

*Seed* oblate or oval, 1.6–1.8 cm. long by 9–10 mm. wide, .25–.5 mm. thick, obtuse at either end, much compressed laterally; *testa* membranous, brown, dilated into a moderately broad wing all round; *tegmen* very thin, membranous, pale-coloured; *micropyle* at one end and *chalaza* at the other, but within the wing; *hilum* on one side below the middle; *raphe* visible as a dark line passing from the

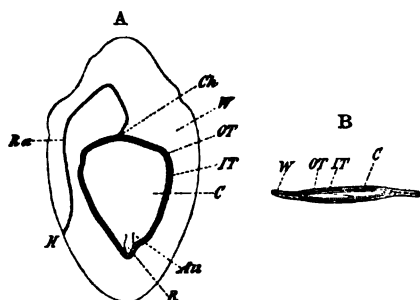


FIG. 628.—*Grevillea Hilliana*,  $\times 2$ . A, longitudinal section of the seed: *H*, hilum; *Ra*, raphe; *Ch*, chalaza; *W*, wing; *OT*, testa; *IT*, tegmen; *C*, cotyledon; *Au*, auricle; *R*, radicle. B, transverse section: *W*, wing; *OT*, testa; *IT*, tegmen; *C*, cotyledon.

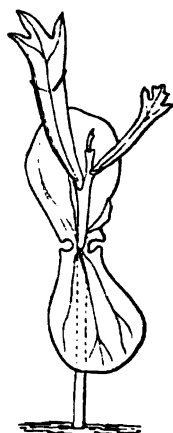


FIG. 629.  
*Grevillea Hilliana*.  
Nat. size.

*micropyle* along one side of the wing and curved round to the chalaza at the apical end of the embryo.

*Endosperm* none.

*Embryo* large, straight, filling the cavity of the seed, colourless; cotyledons broadly obovate, truncate, nearly or quite flat, tapering to a cuneate base, and having unequal ovate acute auricles on each side of the radicle, lying in the broader plane of the seed with their edges to the placenta, and closely applied to each other face to face, exactly opposite or with the laminae oblique to one another; radicle shortly fusiform, tapering to a subacute point, projecting a short way beyond the cotyledons and many times shorter.

**Seedling (fig. 629).**

*Hypocotyl* woody, erect, terete, pubescent with adpressed upturned, brown hairs, 2·8–2·9 cm. long.

*Cotyledons* sessile, obovate, rounded at the apex, auricled at the base and connate, forming a line round the stem, trinerved, ascending, coriaceous, deep green above and shining, paler beneath, glabrous.

*Stem* like the hypocotyl; 1st internode 8·5 mm. long; 2nd 2 mm.; 3rd 4·5 mm.; 4th and 5th each 3 mm.

*Leaves* cauline, simple, alternate, exstipulate, sessile.

No. 1. Always very small, often deformed or linear-oblong, obtuse, mucronate.

Nos. 2 and 3. Cuneate, and tapering to a long petiole-like base, deeply trifid and trinerved in the upper half, glabrous above, deep green and shining, paler beneath, and pubescent with white, upturned, adpressed silky hairs; lobes oblong, acute, or mucronate.

***Grevillea linearis*, R. Br.**  
(fig. 680).

*Hypocotyl* erect, terete, woody, about 8 mm. above the soil.

*Cotyledons* oblong, obtuse, entire, sessile, connate at the base and appearing perfoliate, horizontal when full grown, about 8 mm. long, and 4 mm. wide above the middle.

*Stem* erect, terete, woody; 1st internode 7·5 mm. long; 2nd 9 mm.; 3rd 1 cm.

*Leaves* simple, entire (at least in the early condition of the plant), cauline, alternate, exstipulate, sessile, coriaceous, thinly hairy, light green.

The seedling of *Grevillea punicea*, R. Br., is very similar to that of *G. linearis*.

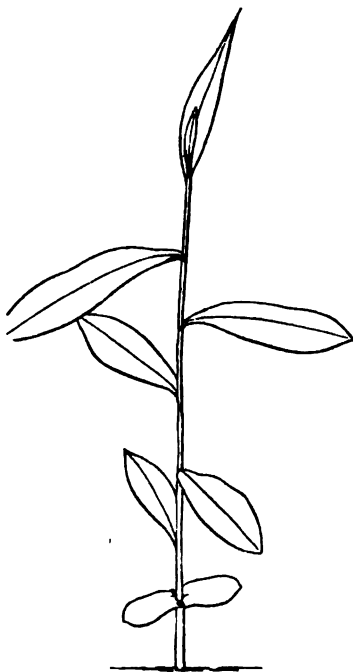


FIG. 680.—*Grevillea linearis*.  
Nat. size.

***Hakea acicularis*, R. Rr.**

*Ovary* shortly stipitate, of one carpel, one-celled, three- to four-ovuled in specimens examined; ovules parietal on the ventral suture, erect or ascending, anatropous; micropyle inferior.

*Fruit* a follicle, broadly ovoid, generally if not always laterally constricted near the apex, more or less deeply furrowed along the ventral suture, surface very uneven with protuberances and cavities, glabrous, the rough epidermis often reticulated with cracks and sometimes falling off in laminae, dehiscing when mature along both sutures, exposing one or generally two seeds, and showing the walls of the fruit to be very thick and bony, with a layer of white, clean, close-grained wood all along the dorsal suture, which splits with a nearly even, clean fracture. This layer of wood causes the fruit to be of very unequal thickness, the dorsal wall being much the thicker.

*Seeds* when geminate, semiobovoid, very rough, tuberculated and gibbous on one side, flat or slightly concave on that towards the other seed, glabrous, black, obliquely winged along the ventral edge and round the apex where it is produced sometimes to the length of 1.5 cm. and 1 cm. in width, and narrowed to an obtuse point, thin, membranous and perforated or reticulated, deep brown, almost black; hilum and micropyle basal at the ventral suture of the follicle, contiguous; raphe and chalaza indeterminable in the mature seed.

*Endosperm* absent.

*Embryo* very large, filling the seed and conforming to it in shape, straight, colourless, rather fleshy; cotyledons obovate, broadly rounded at the apex, rather deeply auricled at the base, otherwise entire, unequal in thickness, one being flat or slightly concave on the side next the other seed, while the other next the side of the follicle is convex or gibbous to correspond to the cavity in the follicle, and somewhat depressed into little holes or cavities; radicle very short, turbinate, obtuse, scarcely protruding beyond the auricles of the cotyledons and pointing into the narrow base of the seed.

**Seedling** (fig. 631).

*Hypocotyl* erect, terete, stout, glabrous, crimson or deep dull red, 2.3–2.8 cm. long.

*Cotyledons* obovate-rotund; apex entire, acutely auricled at the base, thick, fleshy, glabrous, subsessile, deep green above, paler beneath, faintly five-nerved on the under side but venation otherwise indiscernible, often slightly unequal with about 1 mm. difference in

length and width, 1·5–1·2 cm. long, and the same at the widest part, tapering downwards to the radicle; petiole ·25–·5 mm. long.

*Stem* erect, terete, glandular-pubescent, pale green, becoming red, and soon becoming frutescent; 1st internode 9–12 mm. long; 2nd 0·1 mm.; 3rd and all succeeding internodes very short and irregular in length, from 0·4 mm. long, seldom more.

*Leaves* simple, entire, cauline, alternate, exstipulate, sessile, terete or acicular, acute or tipped with a small reddish spine, glabrous except in the shallow furrow corresponding to the midrib beneath, where they are somewhat glandular-pubescent, slightly decurrent at the very base, densely covered with minute colourless points.

Nos. 1–4 and sometimes 5. Small, subulate, acute, or the 4th and 5th linear.

No. 6 and upwards. Gradually longer, acicular.

***Hakea laurina*, R. Br.**

*Hypocotyl* more slender than in *H. acicularis*, 3·8–4·5 cm. above the soil.

*Cotyledons* very similar to those of *H. acicularis* but smaller, longer in proportion and shortly petiolate, light green, opaque, with faint indications of three nerves on the under side; lamina 7–9 mm. long, 6–7·5 mm. wide; petiole semiamplexicaul, somewhat grooved above, slightly convex or nearly flat beneath, ·5–1 mm. long.

*Stem* erect, terete, shrubby, glabrous, reddish, slightly flexuose at least in the young state; 1st internode 4–6 mm. long; 2nd undeveloped; 3rd 5–7 mm.; 4th 4–5 mm.

*Leaves* simple, cauline, alternate (first and second opposite), exstipulate, sessile and narrowed to the base (at least in the young state), alternately, ascendingly incurvinerved, glaucous on both surfaces with a sparse ascending adpressed pubescence (each hair fixed by its middle); petioles none.

Nos. 1 and 2. Opposite, lanceolate, acute, semiamplexicaul at the base, concave above or boat-shaped, ascending or suberect.

Nos. 3 and 4. Spathulate-oblong, acute, entire, spreading longitudinally.

Nos. 5–8. Oblanceolate, tapering to the base, much larger than

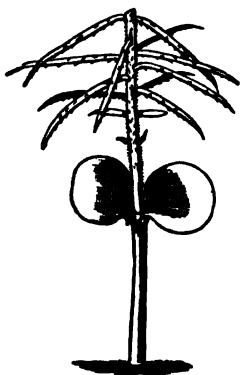


FIG. 681.—*Hakea acicularis*.  
Half nat. size.

those below them, deep glaucous-green with a reddish entire margin, ascending or spreading horizontally, or by a slight twist of the base turned with their edges more or less vertical.

***Hakea eucalyptoides*, Meisn.**

*Hypocotyl* as in preceding species, 1·5–3 cm. long.

*Cotyledons* very like those of *H. acicularis*, light green, indistinctly one-nerved and rather unequal.

*Stem* erect, terete, herbaceous, with a few rather long hairs, ultimately woody; 1st internode 4–10 mm. long; 2nd 3–7 mm.; 3rd 6–12 mm.

*First leaves* lanceolate, very similar to those of *H. laurina*, with a few rather long silky hairs.

***Hakea florida*, R. Br.**

*Hypocotyl* short, 75–2 mm. long, light green or colourless.

*Cotyledons* thick, fleshy, obovate-oblong, obtuse, entire or falcate, cordate at the base, sessile, glabrous, light green, rather unequal, indistinctly one-nerved.

*Stem* erect, terete, herbaceous, ultimately woody, pubescent; 1st internode 1–2 mm. long; 2nd 1–2 mm.; 3rd 5–6 mm.

*First two leaves* very small; others oval-oblong, mucronate, dentate, subsessile, pubescent, light green, trinerved.

***Hakea multilineata*, Meisn., var. *grammatophylla*.**

*Hypocotyl* erect, terete, green, soon becoming brown, woody with the epidermis becoming rent and thrown off, slightly pubescent, glabrescent, 1·8–2·5 cm. above the soil.

*Cotyledons* cuneate, sessile, truncate or retuse at the apex, tapered towards the base and slightly auricled, thinly pubescent on both surfaces and pale green, thick and subcoriaceous, 9·5–11 mm. long, 5·5–7·5 mm. wide near the apex, no venation discernible.

*Stem* erect, terete, somewhat pubescent or hairy, pale green soon becoming brown; 1st internode 4–7 mm. long; 2nd 1–2 mm.; 3rd 7–10 mm.; 4th 5·5–7 mm.

*Leaves* sessile, or a few primary ones tapered to a short petiole, trinerved from near the base, the nerves again giving off strong, ascending branches in the broader leaves, reticulate, pubescent on both surfaces with adpressed whitish hairs, subglabrescent, coriaceous, thickened or somewhat cartilaginous at the margin, glaucous-green above and paler beneath in the lower leaves, but coloured equally in the upper leaves which become vertical by a twist close to their base.



Nos. 1-4. Oblanceolate, acute or cuspidate, horizontal, tapered to a narrow base, rather small.

Nos. 5 and 6. Obovate-oblong, cuspidate, obtuse, horizontal, tapered to a semiamplexicaul base, densely pubescent at the margin near the base with spreading short hairs besides the adpressed scattered hairs.

No. 7. Vertical or horizontal, otherwise like No. 6.

Nos. 8 and 9. Narrower, more acuminate, vertical.

***Stenocarpus salignus*, R. Br.**

*Hypocotyl* erect, quadrangular, glabrous, light green, almost colourless near the soil.

*Cotyledons* broadly obovate-oblong, obtuse, entire, sessile, with pointed auricles, rather thick, glabrous, green, trinerved, each nerve with numerous veinlets.

*Stem* erect, quadrangular, rather downy; 1st internode very short.

***Banksia australis*, R. Br. (fig. 632).**

*Hypocotyl* woody, erect, terete, glabrous, green, soon becoming grey, about 1·2 cm. above the soil.

*Cotyledons* oblong, obtuse, obliquely emarginate, sessile, glabrous, pale green, coriaceous, drawn out into a slender horizontal auricle at the base, 8 mm. long, 5 mm. wide.

*Stem* woody, erect, terete, densely covered with interlacing white hairs when young, and less so or becoming glabrous as it gets old, pale green becoming brown; 1st and 2nd internodes undeveloped; 3rd 4 mm. long; 4th 4·75 mm.; 5th 3·5 mm.; 6th 1·5 mm.; 7th 1 mm.; 8th ·5 mm.



FIG. 632.—*Banksia australis*.  
Half nat. size.

*Leaves* simple, cauline, alternate or opposite or by the suppression of the internodes verticillate or subverticillate, exstipulate, thinly felted with white hairs above and a white tomentum beneath, coriaceous; petioles short, channelled above, thickened at the base.

Nos. 1 and 2. Opposite, cuneate, serrate-dentate above the middle, 1·7 cm. long.

No. 8. Oblanceolate, tapering to the base, serrate-dentate above the middle and tridentate at the apex; teeth spinous.

No. 4. Narrowly obovate-cuneate, otherwise like the last.

No. 5. Similar, but larger.

No. 6. Obovate, cuneate at the base, otherwise like No. 8.

Nos. 7 and 8. Similar, but larger; No. 8, 6·9 cm. long.

***Banksia speciosa*, R. Br. (fig. 688).**

*Hypocotyl* erect, terete, glabrous, stoutest under the cotyledons, deep reddish-crimson, 2–2·5 cm. above the soil.

*Cotyledons* obovate-oblong, obliquely truncate and crenate at the apex, with almost straight and nearly parallel sides, slightly tapered to the base where they are auricled with subulate, acute, slightly declining auricles connate with those of the other cotyledon, trinerved, nerves incurved and uniting with one another some distance below the apex, deep opaque green above, paler beneath or tinged with violet, glabrous, sessile, 1·5 cm. long on one side and 1·95 cm. on the other, 1·2 cm. wide at the apex, 6 mm. at the base exclusive of the auricles.



FIG. 688.—*Banksia speciosa*.  
Nat. size.

*Stem* erect, terete, hairy, reddish when young, ultimately shrubby; 1st and 2nd internodes rather compressed, about ·5 mm. long.

*Leaves* alternate, alternately and ascendingly penninerved, deep green above and densely hairy or almost villous, white with tomentum beneath, revolute at the margins; petiole semiterete, flattened above, densely hairy with jointed hairs, somewhat margined above by the decurrent base of the lamina.

Nos. 1 and 2. Cuneate, pinnatifid with two, rarely three, triangular, obtuse, ascending coarse teeth or lobes on each side.

# THYMELÆACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 186.

*Fruit and Seed.*—The ovary is superior, one-celled and one-ovuled, or in the tribes Phaleriæ and Aquilariæ two-celled with one ovule in each cell. The ovule is inserted laterally near the apex of the cavity, pendulous and anatropous with a ventral raphe. The fruit is nut-like, baccate, or drupaceous and indehiscent, except in the tribe Aquilariæ. The seed is solitary, pendulous or laterally fixed. The testa is coriaceous or rarely membranous, with a distinct membranous inner layer. Endosperm is copious or scanty and fleshy or altogether wanting. The embryo is straight, and large, with fleshy, often thick cotyledons, while the radicle is short and superior. Exceptions from the above characters occur in two anomalous genera, *Octolepis* consisting of a single species with a four-celled ovary containing one ovule in each cell; and *Gonystylus* with a four- or five-celled ovary, each cell with one ovule.

A type of the Order is represented by *Daphne Mezereum*. The seed is obovoid, pendulous and attached to the placenta by a broad flattened funicle near the apex. The tegmen is very thick, while the endosperm is reduced to a thin layer investing the large fleshy embryo. The cotyledons are plano-convex, and slightly auricled at the base, where the short stout radicle is situated.

## *Daphne Mezereum*, L.

*Ovary* of one carpel, one-celled, one-ovuled; ovule pendulous from near the apex of the cell, anatropous; micropyle superior.

*Fruit* a berry, ovoid or subglobose, glabrous, green but becoming scarlet as it matures, and shining, one-celled, one-seeded; epicarp and endocarp thin; mesocarp juicy or pulpy and orange-yellow or scarlet.

*Seed* obovoid, suspended by a short funicle from near the apex of the cell, glabrous, closely conforming to the interior of the berry; testa thin, membranous, pale-coloured, easily detached from the much thicker and subcrustaceous tegmen, deep brown, almost black and shining when fresh, but dull brown when dry; raphe

forming a conspicuous white line along the ventral side of the pale testa; chalaza apical and inferior, conspicuous, pale-coloured, yellowish-white; hilum and micropyle contiguous, basal to the seed and superior.

*Endosperm* in the mature seed very scanty, forming an extremely thin yellow film or membrane over the embryo resembling a third coating of the seed, with a thicker, whiter (yellow when dry), fleshy ring around the radicle.

*Embryo* comparatively very large and almost filling the seed, straight, fleshy, colourless; cotyledons hemispherical or more often semiovoid, strongly plano-convex, minutely auricled at the base, otherwise entire, each occupying half of the seed, lying with their backs to the raphe, and consequently to the placenta, or slightly obliquely to it; radicle very short, turbinate, obtusely pointed, protruded about one-half to two-thirds its length beyond the auricles of the cotyledons, and lying in the subacute tip of the seed, surrounded by a thickish layer of endosperm, and close to the micropyle.

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## ELÆAGNACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 203.

*Fruit and Seed.*—The ovary is superior but enclosed in the base of the perianth, and is one-celled, one-ovuled. The ovule is basal, erect and anatropous. The fruit is enclosed in the persistent base of the perianth which becomes thick, fleshy and ultimately baccate, resembling in outward appearance a true berry. The wall of the fruit proper is thin, membranous and entirely filled by the large solitary seed. The testa of the latter is thickened, and crustaceous or hardened. The endosperm is very scanty, and membranous, usually most abundant around the radicle, or it may be altogether wanting. The embryo is large, straight, conforming to the seed, with thick and fleshy plano-convex cotyledons, and a very short, stout, inferior radicle.

The seed of *Hippophaë rhamnoides* is obovoid, slightly notched at the basal hilum, and surrounded by a depressed line, apparently caused by a ridge in the pericarp during the early stages of growth. The testa is of great thickness,

hard and shining black. The embryo conforms to the seed and is only surrounded by a thin film of endosperm except around the radicle, where endosperm is necessary to fill the space owing to the shortness of the auricles of the cotyledons. In the early growing state of the fruit, the persistent base of the perianth grows at a rate proportionate with that of the ovary which completely fills it. The testa is of great thickness; the tegmen covers a thick layer of perisperm, then follows a thicker layer of endosperm in the embryo-sac, and only slightly shorter than the perisperm just before the fruit attains its full size. The embryo at this stage is half as long as the endosperm, with broadly oval, thin plano-convex cotyledons. The radicle is relatively long compared with the cotyledons. The perisperm and most of the endosperm disappears when the embryo reaches its full size. The neck of the persistent perianth is lined with hairs internally.

The baccate perianth of *Elæagnus longipes* is broadly oblong-oval and densely lined all over the internal surface with interlacing, strong, cottony hairs. The inner layer of the perianth is also hardened, bony, and strengthened with numerous longitudinal woody ridges forming a complete circle surrounding the true fruit which conforms to the cavity. The seed is ellipsoid in conformity with the fruit, and has a membranous testa. The cotyledons are lanceolate, obtuse, deeply auricled at the base, so as to occupy the space around the radicle, plano-convex, and completely fill the seed, endosperm being altogether absent.

*Seedlings.*—The cotyledons of *Hippophaë rhamnoides* (fig. 635) are oblong, obtuse, entire in the early stages but ultimately more or less distinctly and irregularly emarginate, sessile, or very shortly petiolate, slightly auricled at the base, fleshy, aerial, somewhat plano-convex and glabrous. The leaves are opposite in the seedling stage, the first pair being lanceolate, followed by three or more pairs which are elliptic and obtuse. All are covered with shortly stalked, peltate scales; on the adult the leaves are alternate.

The cotyledons of *Elæagnus angustifolia* var. *microcarpa* (fig. 634) are oblong, obtuse, deeply auricled at the base but otherwise entire, thick and fleshy with indiscernible venation.

They differ from those of *Hippophaë rhamnoides* in being more deeply auricled at the base, but more especially in having semiterete petioles 4–9 mm. long. The first four leaves are lanceolate-oblong, penninerved and covered with stellate scales. The first two are opposite, the rest alternate; this is also the case sometimes with *Elæagnus hortensis*, where the first two are lanceolate; the cotyledons exhibit an indistinct midrib, but are otherwise similar to those of the last-named species, except that the petioles are shorter.

*Elæagnus longipes*, A. Gray.

*Fruit* an achene, enclosed in the fleshy or baccate perianth, furnished with stellate scales that do not cover the whole surface, yellow or nearly scarlet when mature; middle layer of perianth juicy or pulpy; inner layer hardened or bony and strengthened with numerous longitudinal, strong, thickened ridges, and covered on the inner face with a dense interlacing layer of tough cottony hairs; pericarp thin, membranous, tipped with the remains of the style, pale-coloured.

*Seed* ellipsoid, rather narrow, conforming to the interior of the ovary, which again conforms to the interior of the calyx-tube; testa thin, membranous, whitish; raphe passing along the whole length of the seed and forming a conspicuous ridge; funicle short; chalaza apical and superior, conspicuous; hilum and micropyle basal, inferior, contiguous.

*Endosperm* absent.

*Embryo* straight, large and occupying the whole interior of the seed, colourless; cotyledons lanceolate or oblong, obtuse, rather deeply auricled at the base, otherwise entire, plano-convex and each occupying half of the seed, lying with their edges to the raphe (in all the specimens examined); radicle oblong or ellipsoid, obtuse, about half its length protruded beyond the auricles of the cotyledons and much shorter than the latter, occupying the narrow base of the seed.

*Elæagnus angustifolia*, L., var. *microcarpa* (fig. 684).

*Hypocotyl* erect, terete, glabrous, rarely with a few stellate scales, pale green, 3–3.5 cm. above the soil.

*Cotyledons* oblong, obtuse, entire at the apex and rounded, deeply auricled at the base, thick, fleshy, with indiscernible venation, somewhat shining, pale opaque green above, bright green beneath, mostly glabrous or with stellate scales on the petioles; lamina 1–

1.35 cm. long, 5–7 mm. wide; petioles semiterete, slightly grooved above, tapering slightly upwards, pale green, 4–9 mm. long.

*Stem* erect, terete, densely covered with stellate or radiate scales, ultimately shrubby; 1st internode 6–9.5 mm. long.

*Leaves* simple, entire, cauline, alternate (first two opposite or nearly so), exstipulate, petiolate, alternately and ascendingly penninerved, densely covered beneath with stellate scales, and on the upper side at least in the seedling; petioles short, semiterete, slightly grooved or merely flattened above, densely stellate-scaly like the leaves.

Nos. 1–4. Lanceolate-oblong, acute or obtuse, alternately and ascendingly penninerved, with few and indistinctly visible nerves incurving and uniting in a single intramarginal wavy line.



FIG. 684.—*Elæagnus angustifolia* var. *microcarpa*. Nat. size.

The seedling of *Elæagnus hortensis*, M. B., closely resembles the preceding.

### ***Hippophaë rhamnoides*, L.**

*Fruit* enclosed in the baccate perianth; pericarp thin, membranous, pale-coloured, traversed along two sides with a thickened yellow nerve or ridge uniting beneath the persistent style and also at the base of the seed, one-seeded, indehiscent. The baccate perianth becomes enlarged at the base, and globular, ultimately fleshy, pulpy or almost deliquescent internally.

*Seed* obovoid, marked on two sides with a vertical depressed line caused by the ridges on the pericarp, slightly unequal at the base; testa very much thickened and hardened, shining black, smooth; hilum basal between the unequal lobes of the emarginate base.

*Endosperm* in the mature seed forming a very thin layer on the inner surface of the testa, except at the base where it forms a thick sheath round the radicle.

*Embryo* straight, large, subobovoid, fleshy, occupying almost the whole of the seed; cotyledons plano-convex, closely occupying the

interior of the seed, slightly auricled or cordate at the base; radicle short, stout, subterbinate, obtuse, embedded in a thick layer of endosperm, close to the hilum and pointing into the longer lobe of the seed at the base of the fruit.

**Seedling (fig. 685).**

*Hypocotyl* erect, terete, pale green, glabrous, about 1·7–2·6 cm. above the soil.

*Cotyledons* oblong, obtuse, entire or minutely and irregularly emarginate, slightly auricled at the base, somewhat plano-convex, fleshy, glabrous, dull green above, light green beneath and somewhat shining, very shortly petiolate, with indistinguishable venation, or a midrib discernible in a younger state; lamina 7–8·5 mm. long, 4·5–5·5 mm. wide; petiole 1–1·25 mm. long.

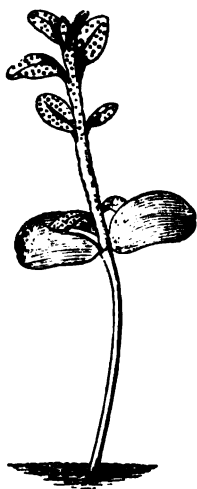


FIG. 685.  
*Hippophaë rhamnoides*.  
Half nat. size.

*Stem* erect, terete, pale green, rough or scurfy with scales, ultimately woody; 1st internode 3 mm. long; 2nd 7 mm.; 3rd 3·75 mm.

*Leaves* simple, entire, cauline, alternate (opposite in the seedling state), exstipulate, shortly petiolate, covered with very shortly stalked scales, giving the leaves a silvery appearance on both surfaces, somewhat fleshy and opaque in the seedling stage, alternately penninerved; petiole channelled on the upper side, convex on the back, silvery like the lamina, 1 mm. long in the seedling.

First pair lanceolate, obtuse, with the midrib only discernible.

Second to fourth pairs elliptic, obtuse, showing a distinct midrib, but the few lateral nerves present are hardly discernible with transmitted light.



## SANTALACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 217.

*Fruit and Seed.*—The ovary is inferior from the first, or becomes so during the flowering period, or in the tribe Anthoboleæ the disc only surrounds it at the base; in all cases it is one-celled. The ovules vary from two to three, and are pendulous from or near the apex of a central, filiform or thickened placenta; or in the Anthoboleæ the ovule is solitary, central, basal and erect.

The fruit is nut-like or often drupaceous, and is indehiscent. The exocarp is slender and dry, sometimes fleshy or succulent, sometimes thickened; while the endocarp is crustaceous, hardened or bony. The seed is globose or obovoid, and smooth, rugose, or deeply many-furrowed. The testa is very thin and not easily distinguishable, or is absent or apparently so. Endosperm is copious and fleshy, often white. The embryo is often oblique, not strictly central, short or linear, very often terete, and straight or scarcely incurved. The cotyledons are semiterete or rarely slightly dilated and longer or shorter than the superior radicle. Sometimes the embryo is minute and scarcely discernible.

Exceptional cases occur in *Cervantesia* and *Santalum* where the ovary is superior or rarely immersed in the disc. The endocarp is plicate, and in *Henslowia* is intruded into furrows of the seed. *Santalum ellipticum* may be regarded as typical of the Order. The fruit is obovoid-elliptic or subglobular and crowned by a rim, the persistent portion of the calyx. The exocarp is comparatively thin when dry, and the endocarp is thick and woody. The seed is ovoid, conforms to the interior of the cavity, and is apparently without a testa. The greater part of it consists of a mass of fleshy endosperm. The cotyledons are ovate-oblong, and in the specimen observed several times shorter than the radicle. The latter is very much thicker than the cotyledons at its base, and tapers to a slender point.

*Seedlings.*—The cotyledons of all the seedlings coming

under my notice are narrowly linear. Those of *Osyris compressa* (fig. 636) are revolute at the edges and thus appear still narrower. They are 2-2.25 cm. long and 2-2.5 mm. wide. The leaves are opposite, decussate, very closely arranged and closely resemble those of a species of *Buxus* both in size, shape, texture and colour. The first two pairs are lanceolate-elliptic, followed by at least seventeen other pairs which are obovate, and generally cuspidate. The cotyledons of *O. abyssinica* are similar to those of the last and yellowish-green. The first pair of leaves are lanceolate and acute.

The seedlings of *Santalum album* are very similar to those of the foregoing with respect to the cotyledons and the mode of germination. The hypocotyl is elongated and in germinating carries up the fruit on the cotyledons. In the case of *Santalum* at least the cotyledons often have a difficulty in getting clear of the fruit notwithstanding their narrowness, and often become torn off in the process. Their narrowness appears to be due to the difficulty of exit from the small opening of the woody fruit; for there is plenty of space inside to allow of their attaining a much greater width.

***Santalum ellipticum*, Gaud.**

*Ovary* inferior, one-celled, two- to three-ovuled; ovules pendulous, anatropous; micropyle superior.

*Fruit* a drupe, obovoid-elliptic, with four ridges at the base, and smaller intermediate ones, and as many prominences near the apex which is crowned with an annular rim, the persistent base of the perianth, within which it ends with a conical point; one-celled, one-seeded, indehiscent; exocarp comparatively thin; endocarp woody, pale-coloured.

*Seed* conforming to the cavity of the ovary, and apparently without a testa.

*Endosperm* copious, fleshy, white, constituting the greater part of the seed, wrinkled or furrowed longitudinally when dry.

*Embryo* straight, thin or narrow, less than half the length of the seed (probably imperfectly developed), yellowish; cotyledons ovate-oblong, obtuse, entire, sessile, several times shorter than the radicle, and narrower than its thickest part; radicle four to five times as long as the cotyledons, stout at the origin of the cotyledons

and tapering to a long slender tip which lies immediately within the apex of the endosperm.

N.B.—In the fruit figured in Le Maout and Decaisne, p. 723, the long narrow cotyledons reach nearly to the base of the seed and are twice the length of the radicle.

*Osyris compressa*, DC. *fil.* (fig. 636).

*Hypocotyl* woody, erect, terete, glabrous, brown, 1·7–2 cm. above the soil.

*Cotyledons* linear, obtuse, rigid, with revolute margins, pale subglaucous-green, sessile, 2–2·25 cm. long, 2–2·5 mm. wide.

*Stem* woody, erect, terete at the base, quadrangular upwards, glabrous, pale yellowish- or subglaucous-green, ultimately brown; 1st internode 1·85 cm. long; 2nd 8·5 mm.; 3rd 1·1 cm.; 4th 5·5 mm.; 5th 5·5 mm.; 6th 4·5 mm.; 7th 6 mm.; 8th 7 mm.; 9th 1 cm.; 10th 9 mm.; 11th and 12th each 6·5 mm.; 13th and 14th each 6 mm.; 15th, 16th and 17th each 7·5 mm.

*Leaves* simple, entire, cauline, opposite, exstipulate, sessile, thick, coriaceous, glabrous, pale glaucous-green, almost yellowish, obscurely alternately penninerved.

First and second pairs lanceolate-elliptic, acute.

Third to seventh pair inclusive, obovate, obtuse, apiculate or minutely cuspidate, convex above and concave beneath.

Eighth to nineteenth pair inclusive, obovate, obtuse, minutely cuspidate, flat.

*Osyris abyssinica*, Hochst.

*Hypocotyl* stout, thickened considerably near the base, reddish, 2·5–2·6 cm. long.

*Cotyledons* similar to those of *O. compressa*, light yellowish-green.

*Stem* flattened, herbaceous, ultimately woody, reddish-green, glabrous; 1st internode 2–10 mm. long; 2nd shorter.

*First leaves* ovate-lanceolate, acute, petiolate, glabrous, yellowish-green, with a reddish tinge near the edges, indistinctly one-nerved.



FIG. 636.  
*Osyris compressa*.  
Half. nat. size.

## EUPHORBIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 239.

*Fruit and Seed.*—The ovary is superior, usually three-celled, often two- to four-celled, and sometimes one- or five- to many-celled. The ovules are solitary in each cell or geminate and collateral, pendulous, anatropous, inserted on axile placentas with a ventral raphe and superior micropyle, rarely having a dorsal raphe with the micropyle close to the placenta. The funicle is very frequently developed into a cellular, scale-like, or hooded arillode, sometimes expanded and covering the ovule wholly or in part. The fruit is capsular and falls away at maturity into as many cocci as there are cells, leaving the axis free. Sometimes it is baccate or drupaceous, divided into cells, and indehiscent, very rarely breaking up into two or three pyrenes; or it may by abortion be one-celled and one-seeded. The exocarp is thin or thickened and fleshy; while the endocarp is cartilaginous, crustaceous or hardened. The seeds equal the number of cells or are fewer by abortion; they have a crustaceous, rarely woody or membranous testa. The endosperm is copious and fleshy or rarely cartilaginous or papery. The embryo is central and straight, rarely incurved, and almost equals the endosperm in length, and sometimes in breadth. The cotyledons are broad and foliaceous, rarely fleshy, or narrow and semiterete, very rarely thick and fleshy, or very broad and twisted. The radicle is superior, and short or rarely elongated; and when the cotyledons are very broad and auricled at the base, it is mostly enclosed or surrounded by the auricles.

The species of *Euphorbia* might also be divided into those having pitted, smooth, or tubercular seeds. The seeds may be divided into three groups.

The seed of *E. exigua* is obtusely tetragonal and deeply pitted on the two faces obliquely facing the placenta. The cotyledons represent the narrowest type. They are oblong, obtuse, plano-convex, rather narrower and much shorter than the radicle. The seed of *E. Lathyris* is shortly oblong, slightly

compressed, rather truncate at either end, and obliquely so at the hilum where a semi-globular arillode is situated. The cotyledons are rather wider than in the last case and much longer than the radicle. The latter condition is again reversed in *E. Peplus* in which the radicle is twice as long as the cotyledons. The latter are, however, much wider and oval with their backs to the placenta as in the three previous cases. The seed is oblong, bluntly ridged longitudinally, deeply pitted with circular depressions, and a long furrow on each side of the raphe on the ventral aspect. The broadly oval cotyledons of this species form a connecting link with the next group.

The seed of *Euphorbia splendens* is globose-oblong, tumid, and covered all over with small warts or elevations. The embryo of this species falls considerably short of the endosperm. The cotyledons are plano-convex, suborbicular, and nearly as wide as the endosperm. The seed of *E. platyphylla* is subglobose and the embryo very similar to that of the last, but the cotyledons are relatively longer, and somewhat exceed the radicle. The seed of *E. Lagasce* is oblong, terete and rather truncate at either end. The cotyledons are broadly oblong, and longer than the radicle. The seed of *E. macrorhiza* is oblong, compressed, elliptical in transverse section, and truncate at both ends. The cotyledons are broad, short, oblong and about equal to the radicle in length.

The third type is very distinct from either of the foregoing as the cotyledons almost equal the seed, both in length and width, nearly dividing the endosperm into halves as occurs in *Sterculia*. A good example is that of *Jatropha Curcas* which has broadly oblong cotyledons deeply auricled at the base and almost completely enclosing the short stout radicle. They are radiately five-nerved from the base, with strong, branching nerves. The endosperm shrinks when dry, and the cotyledons receding with it, a hollow space is left between them. This peculiarity is even more marked in *Hevea brasiliensis*, where the endosperm is more nearly if not quite divided in half.

The cotyledons are oblong, slightly tapered to the base in

conformity with the seed, trinerved and reticulate. The seed is variegated with black blotches and markings on a deep brown or even a pale ashy-grey ground. This is also the case in *Ricinus communis* which has ovoid-oblong, dorso-ventrally compressed seeds surmounted with a globular arillode. The cotyledons are like those of the two previous species, but fall a little short of the length and breadth of the seed. They are five-nerved in the lower half and closely reticulated upwards. The radicle projects a little beyond them.

*Seedlings*.—A considerable number of forms of cotyledons are found in the Order, many of them gradually merging one into the other. Several occur in the genus *Euphorbia* itself, where also the narrowest types are to be met with. The cotyledons of *E. Lathyris* are long, leafy, linear and show the midrib only. The leaves are opposite and four or more of the primary pairs closely resemble the cotyledons except in being larger, and longer. The cotyledons of *E. exigua* (fig. 637) are linear or spathulate-linear and closely resemble the first ten leaves except in being longer. The first pair only are opposite. The cotyledons of *E. Peplus* are oblong-linear and the smallest observed in the Order. The leaves are alternate, except the first pair, and vary between obovate and obovate-elliptic. The bracts are broadly ovate. The cotyledons of *Buxus sempervirens* (fig. 639) are oblong-linear or spathulate; and the first two pairs of leaves are obovate or elliptic.

The cotyledons of *Euphorbia Lagascæ* are large, oblong, entire or slightly emarginate, and penninerved with ascending lateral veins. In form and venation they seem to stand alone.

Those of *E. Myrsinites* are broadly oval, entire and trinerved. The first pair of leaves are similar, but smaller, with more numerous ascending veins. A considerable number of species have broadly oblong-oval cotyledons as typified by *Phyllanthus flaccidus* (fig. 640). They also in this instance are trinerved at the base, and have above several other, long, incurved nerves. The leaves of the seedling are very similar but larger and alternate. The third to the fifth on the primary axis are reduced to small scales, bearing in their

axils leafy branches. The cotyledons of *Petalostigma quadri-locularis* are larger and taper slightly at the base into hairy petioles, but are otherwise similar to those of the last species. The leaves are considerably smaller, oval and hairy. The cotyledons of *Phyllanthus mucronatus* are very similar to those of its congener mentioned above. The first four leaves are smaller and obovate. The cotyledons of *Euphorbia heterophylla* also conform to this type. Those of *E. platyphylla* slightly depart from it in being wider at the base, oblong-ovate, and alternately penninerved. The two primary leaves are small and obovate. The cotyledons of *Mercurialis annua* are similar, in being broadly oblong-ovate, but trinerved in the lower half. The first pair of leaves are comparatively large, ovate, serrate and thinly hairy.

The cotyledons of *Euphorbia splendens* (fig. 638) are more nearly orbicular than those of any other species in the Order coming under my observation. They are also entire or rarely slightly emarginate and obscurely trinerved. The first three leaves are elliptic, finely acuminate and closely penninerved with the nerves incurved. The hypocotyl becomes fleshy and tapshaped while the seedling is yet quite small and has developed but a few leaves. Probably the succulent and leafless species would even be more notable in this respect. During germination the seed is frequently carried up on the cotyledons, and their growth as well as the swelling endosperm cause the crustaceous testa to split along the greater part of its length exposing the endosperm which continues to cover the cotyledons for some time till mostly absorbed. The same or much the same thing occurs in *E. Peplus* and also in *Eschscholtzia* amongst the *Papaveraceæ*.

The cotyledons of *Acalypha virginica* are orbicular, widely and shallowly emarginate, and trinerved with the primary nerves much branched. The first pair of leaves are opposite, widely and shallowly crenate. The cotyledons of *Dalechampia capensis* (fig. 645) are also orbicular, sometimes oblong, but they are very subject to malformation, in being undulated, erosely emarginate, often oblique or irregularly cut away at the base, or elsewhere, and variously twisted.

A number of species having more or less succulent or fleshy

stems and large seeds are notable for the great size and foliaceous character of their cotyledons. Those of *Ricinus communis* (fig. 644) are five-nerved, ovate-oblong or oblong, the shape varying even in the same plant. The first two leaves are ovate, palmately seven-nerved and lobed at the base, with a longer terminal lobe and acuminate. Every division is finely serrated. *Jatropha podagrica* (fig. 643) is notable for its long and succulent hypocotyl. The cotyledons are broadly oblong, trinerved, and slightly auricled at the base. As in other cases the auricles take their origin in the seed, when they occupy the space on each side of the radicle. The first leaf is roundly ovate, peltate, seven-nerved, very blunt and entire. The cotyledons of *Jatropha Curcas* (fig. 642) are rotund-oblong, entire or emarginate, subauricled at the base, and seven- to nine-nerved. The first leaf is cordate-ovate, and coarsely dentate. The second and third are cordate, acuminate, seven-nerved and incipiently palmately lobed.

A type distinct from any of the above is met with in *Jatropha multifida*. The cotyledons are large, obovate, fleshy, and remain in the seed which is carried up by the robust and greatly elongated hypocotyl. When dry they are seen to be three- to five-nerved. The first leaf is digitately seven-lobed; the second nine-lobed; and the third and fourth seven-lobed. The divisions of all are pinnatifid, with the ultimate segments subulate, lanceolate or linear. The hypocotyl of *Hevea Spruceana* (fig. 641) is undeveloped and the cotyledons are subterranean, remaining in the seed till they decay. Both the seeds and the cotyledons are large, and the latter are petiolate as was the case in *Jatropha multifida*, in order to facilitate their exit and that of the plumule. The primary internode of the stem varies from 12–20 cm. in length; but the second one is only about 3 mm. long. The first two leaves are opposite, and digitately trifoliate, with oblong-lanceolate, acuminate, entire, and finely penninerved leaflets. The third leaf is alternate, similar in form but smaller.

***Euphorbia Lathyris*, L.**

*Capsule* trilobed, glabrous, glaucous when fresh, three-celled, three-seeded, dehiscing with elasticity and force septicidally and



loculicidally ; exocarp thick, hard or subwoody, separating from the thin pale-coloured endocarp.

*Seed* shortly oblong, thick but slightly laterally compressed, arillate, somewhat variegated with brown, sculptured all over, suspended from the axile placenta at the apex of the cell ; testa thick and crustaceous ; tegmen thin and membranous ; hilum and micropyle superior on the pendulous seed and contiguous ; raphe ventral ; chalaza inferior ; arillode whitish, forming a slightly elevated cap or shield on the hilum, crenate at the margin and having a groove on its under side to accommodate the raphe.

*Endosperm* copious, fleshy, whitish.

*Embryo* straight, embedded in the endosperm and somewhat shorter than the latter ; cotyledons oblong, obtuse, entire, plano-convex, closely applied face to face, lying in the broader way of the seed with their edges to the raphe and axis, much narrower than the endosperm but somewhat broader than the radicle ; radicle oblong or cylindrical, obtuse, about equalling the cotyledons in length or shorter, central or lying somewhat obliquely so as to be in the longer axis of the seed, and point to the micropyle at one corner above the cap-like arillode.

### Seedling.

*Primary root* long, stout, tapering, fleshy, subflexuose, with fleshy, flexuose, lateral rootlets.

*Hypocotyl* erect, terete, fleshy, glabrous, purple and shining, with a few scattered small red protuberances like bilobed glandular processes, about 8·8 cm. long, but very variable according to cultural treatment.

*Cotyledons* long, foliaceous and slightly smaller than, but precisely similar to the first pair of leaves, sessile, linear, obtuse, one-nerved, glabrous, deep subglaucous-green above, glaucous beneath, subconnate at the base forming a narrow rim around the stem, horizontal, 2·1–5 cm. long.

*Stem* erect, terete, fleshy, biennial, glabrous, glaucous or suffused with a purplish tint ; 1st internode 1·1 cm. long ; 2nd and 3rd each 1 cm. ; 4th 6 mm. ; 5th and 6th 4 mm.

*Leaves* simple, entire, cauline, opposite, decussate, exstipulate, very shortly petiolate or subsessile, horizontal, deep subglaucous-green above with a white midrib, glaucous beneath, very glabrous, linear-oblong, obtuse, apiculate, with the upper ones wider and longer, flat or the younger ones slightly grooved on the upper side,

all similar in shape to the cotyledons and first pair of leaves till near the inflorescence.

*Bracts* large, ovate and lanceolate, acuminate, subcordate at the base.

***Euphorbia exigua*, L.**

*Fruit* capsular, falling away from the persistent axis into three two-valved cocci, each containing one seed.

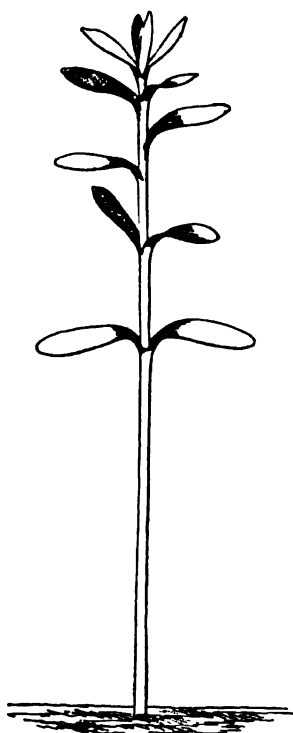


FIG. 687.—*Euphorbia exigua*,  
× 2.

*Seed* shortly oblong, small, obtusely tetragonous in transverse section, glaucous or whitish, and deeply pitted all over the two faces nearest the axis; hilum depressed at the apex of the ventral aspect; raphe ventral on the ventral angle; chalaza basal.

*Endosperm* copious, fleshy or almost farinaceous, white, surrounding the embryo.

*Embryo* straight, central, nearly as long as the endosperm, but much narrower, colourless; cotyledons oblong, obtuse, entire, plano-convex, much shorter than the radicle; radicle cylindrical, obtuse, but narrowed to the point, much longer than the cotyledons and as broad or slightly broader in the middle, close to the apex of the endosperm, and the hilum of the seed.

**Seedling (fig. 687).**

*Hypocotyl* glabrous, bright green, 1.8–2.4 cm. above the soil.

*Cotyledons* spatulate-linear or strictly linear, obtuse, entire, narrowed to the base and connate, glabrous, glaucous above, bright green beneath and shining.

*Stem* erect, terete, glabrous, bright green, annual; 1st internode 7.5 mm. long; 2nd 4.5 mm.; 3rd 1.5 mm.; 4th 2 mm.

*Leaves* alternate (1st and 2nd opposite), entire, sessile, narrowed to the base, with a distinct midrib seen only by transmitted light, glabrous, glaucous above, bright green beneath.

Nos. 1–10. Linear, subacute, narrowed towards the base.

**Euphorbia Peplus, L.**

*Capsule* as in *E. Lathyris*, but the pericarp does not split into two distinct layers when mature.

*Seeds* comparatively small, oblong, capped by a small, white, funicular arillode, somewhat angled longitudinally, deeply pitted with circular depressions and a long oblong one on each side of the raphe on the ventral aspect, grey or glaucous, slightly depressed or truncated at either end; testa subcrustaceous, tegmen thin and membranous; raphe ventral; chalaza inferior, orbicular, and convex or somewhat elevated, and seated in an apical depression; hilum and micropyle superior, with the former lying in a depression formed by the arillode, and oval in outline.

*Endosperm* copious, fleshy, whitish.

*Embryo* comparatively large, straight, colourless, central, somewhat shorter than the endosperm; cotyledons oblong, orbicular, entire, plano-convex or nearly flat, lying in the endosperm with their backs to the axis; radicle oblong, much narrower and also longer than the cotyledons, tapering somewhat to an obtuse point, which lies close to the micropyle.

*Germination*.—The radicle pushes into the soil, fixing the young plant there, and develops root-hairs. The hypocotyl arches, and as it rises up pulls the cotyledons out of the seed, which splits irregularly during the process so as to facilitate their exit. In moist soil and a moderately high temperature, the seeds germinate in nine days.

On the second day after appearing above the soil, the lower part of the hypocotyl is straight and stout; the upper part is still curved downwards and much more slender. The cotyledons immediately after leaving the seed are narrowly oblong, obtuse, entire, glabrous, pale green, and sessile.

Four days after appearing above soil the hypocotyl is nearly straight, and the cotyledons are somewhat larger, oblong, obtuse, entire and very shortly petiolate, with two short lateral nerves at the base and one to two alternate ones upwards.

**Seedling.**

*Primary root* normal, annual.

*Hypocotyl* pale green below, purple upwards, tapering into the root, 1.9 cm. long.

*Cotyledons* linear-oblong, obtuse, entire, tapering into the petiole which is short and grooved above, 8 mm. long including the petiole.

*Stem* very similar to that of *E. exigua*.

*Leaves* petiolate, subglaucous-green above, glaucous beneath, obovate or varying to obovate-elliptic, obtuse, sometimes though rarely emarginate.

*Bracts* broadly ovate.

***Euphorbia Myrsinites*, L.**

*Hypocotyl* 2-3 cm. long, light green.

*Cotyledons* broadly oval, obtuse, entire, shortly petiolate, glabrous, dark green above, lighter beneath, indistinctly trinerved.

*Stem* erect, terete, herbaceous, light green, glabrous; 1st internode 3-5 mm. long; 2nd shorter.

*First leaves* opposite, sessile, entire, obovate-oblong, obtuse, glabrous, subglaucous-green, indistinctly pinnatinerved.

***Euphorbia heterophylla*, L.**

*Hypocotyl* thicker towards the base, light green stained with red towards the soil, 1.5-2.25 cm. long.

*Cotyledons* oblong, obtuse, entire, petiolate, glabrous, light green, distinctly pinnatinerved.

The seed splits transversely at the hilum, and the cotyledons have often a considerable difficulty in getting rid of the testa, for which purpose they are often thrown into folds.

The membranous remains of the endosperm frequently stay on the cotyledons long after the testa has been thrown off.

***Euphorbia platyphylla*, L.**

*Capsule* small, roundish, warted, one-seeded.

*Seed* subrotund or obovate, slightly flattened laterally, 1-1.25 mm. long; testa crustaceous, light brown, smooth, slightly thickened near the hilum; hilum rather conspicuous.

*Endosperm* copious, fleshy.

*Embryo* straight, embedded in endosperm; cotyledons oval or suborbicular, obtuse, entire, plano-convex, closely adpressed, lying in the broad way of the seed with their edges to the axis; radicle obtuse, entire, terete, about equal in length to the cotyledons.

**Seedling.**

*Hypocotyl* 3-4.5 cm. long, light green or colourless, with often a slight tinge of red near the base.

*Cotyledons* ovate-oblong, obtuse, entire, membranous, petiolate, glabrous, light green and, like the leaves, indistinctly pinnatinerved.

*Stem* erect, terete, glabrous; 1st internode 3-4 mm. long.

*Primary leaves* entire, alternate, obovate, obtuse, petiolate, glabrous, light green, subglaucous beneath, pinnatinerved.

*Euphorbia splendens*, Boj.

*Capsule* as in *E. Peplus*.

*Seed* shortly oblong, tumid, almost globose, terminating at the upper and basal part in a short, cuspidate, obtuse point which corresponds to the micropyle, covered all over with little obtuse elevations or points, dull grey, suspended from near the apex of the placenta at the inner angle of the cell; testa thick and subcrustaceous; tegmen thin and membranous; hilum and micropyle contiguous, superior; raphe ventral; chalaza inferior.

*Endosperm* copious, fleshy, whitish.

*Embryo* comparatively large, falling a little short of the endosperm, in which it is embedded, central, colourless or pale yellow; cotyledons subrotund, obtuse, entire, plano-convex, lying in the endosperm with their backs to the axis or placenta (the diameter of the seed being about equal either way); radicle oblong, obtuse, lying in the endosperm with its point close to the micropyle, equalling or slightly longer, but much narrower than the cotyledons.

*Germination*.—An early stage shows the testa splitting deeply into halves by the force of growth of the cotyledons, and the swelling endosperm. If only lightly covered the seed is carried up by the germinating embryo. The seedling appears above soil in about thirteen days.

Nine days after germination the testa and endosperm are not yet thrown off, but the as yet very shortly petiolate cotyledons have increased considerably in size, and are now partly uncovered. The glabrous hypocotyl is somewhat fleshy, has increased greatly in length and thickness, and is pale greenish-yellow.

**Seedling** (fig. 638).

*Primary root* slender, tapering, often flexuose, with a few lateral rootlets.

*Hypocotyl* fleshy, erect, clavate, tumid, glabrous, shining, pale green or deep dull red according to exposure.

*Cotyledons* rotund, entire, petiolate, obscurely trinerved, rarely slightly emarginate, glabrous, deep subglaucous-green above, paler beneath; lamina 8.5 mm. long, 7.5 mm. wide; petiole flattened above, 1.5 mm. long.

*Stem* shrubby, fleshy, full of latex, branching, much angled by the long, stout, spiny stipules, shortly and densely pubescent

when young, afterwards subglabrous, pale green or reddish, ultimately brown or grey; 1st internode 2 mm. long, conspicuously thinner than the hypocotyl; 2nd 1 mm. long; 3rd not developed. Here the first season's growth seems to end.

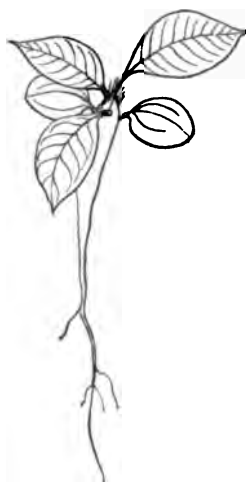


FIG. 688.  
*Euphorbia splendens*.  
Nat. size.

*Leaves* simple, entire, cauline, alternate, stipulate, petiolate, pubescent on the midrib beneath, otherwise glabrous, deep subglaucous-green above, paler beneath and glaucous, alternately penninerved, with ascending nerves, curved at their apex and joining, forming a loop, or obscurely anastomosing; petioles short, pubescent, grooved above and rounded on the back; stipules long, spiny, tapering to an acute point, dilated at the base longitudinally, and compressed laterally; the colour of the branch.

Nos. 1-8. Elliptic, acute, or apiculate.

Ultimate leaves elliptic, or oblong-elliptic, apiculate.

### *Euphorbia macrorhiza*, C. A. Mey.

*Fruit* capsular or splitting up into three cocci separating from the persistent axis, triangular or shallowly trisulcate, glabrous, green, reticulate, ultimately ash-coloured, and tipped with the short persistent style and three bifid stigmas; cocci oblong, obtusely tetragonal, disconnected along the interior angle, with a round opening near the apex of that side, through which the funicle or process of the placenta passes, sometimes splitting along the dorsal suture, crustaceous, brittle.

*Seed* oblong, elliptical. In transverse section, hard, smooth, truncate at both ends, deep brown, slightly variegated with a paler colour, crustaceous, capped with a reniform deep yellow or orange, micropylar arillode, the notch of which stands over the minute hilar spot; raphe ventral, extending to the extreme base of the seed, where the chalaza forms a small circular depression.

*Endosperm* abundant, fleshy, white, surrounding the embryo.

*Embryo* axile, straight, with a well-developed, pointed radicle; cotyledons flattened, or slightly convex on the back, short, oblong, obtuse, entire, fleshy; radicle stout, pointed, about equalling the cotyledons in length.

***Buxus sempervirens*, L. (fig. 689).**

*Primary root* long, tapering, with a few short, fleshy, adventitious rootlets.

*Hypocotyl* erect, terete, suffrutescent, glabrous, pale green, 8·8 cm. long, 1 mm. thick.

*Cotyledons* foliaceous, oblong-linear or spatulate, obtuse, glabrous, deep green, 1·3 cm. long, 8·75 mm. wide, tapering to the base.

*Stem* suffrutescent, erect, quadrangular from the decurrent lines from the petioles, glabrous, pale green; 1st internode 8 mm. long; 2nd 2·5 mm.

*Leaves* simple, cauline, opposite, decussate, exstipulate, shortly petiolate, bright green, glabrous, entire, evergreen; petioles slightly grooved above, 1 mm. long.

First and second pairs alike, obovate or subelliptic.

***Phyllanthus flaccidus*, Thwaites (fig. 640).**

*Hypocotyl* erect, terete, glabrous, closely mottled with red on a pale green ground, 1·4–1·6 cm. above the ground, more or less covered with minute crystalline papillæ.

*Cotyledons* oblong-oval, obtuse, entire, alternately incurvinerved, petiolate, glabrous, deep green, firm, horizontal; lamina 9–10·5 mm. long, 4·5–5·5 mm. wide; petiole biconvex or somewhat flattened above, minutely papillose, 1–1·5 mm. long.

*Stem* erect, terete, slender at this stage, glabrous, minutely papillose, and mottled with red on a pale green ground, ultimately woody; 1st internode 9–11 mm. long; 2nd 4–5 mm.; 3rd 4–5 mm.; 4th 6·5–7·5 mm.

*Leaves* simple, entire, cauline, alternate, stipulate, petiolate, scattered on the primary stem, and distichous on the lateral branches, alternately incurvinerved and reticulate, glabrous, revolute at the margin, minutely dotted with pale grey on a deep green ground, glaucous beneath; stipules minute, triangular-subulate, acute, pale green, or pinkish, hyaline at the margin; petioles terete, smooth,

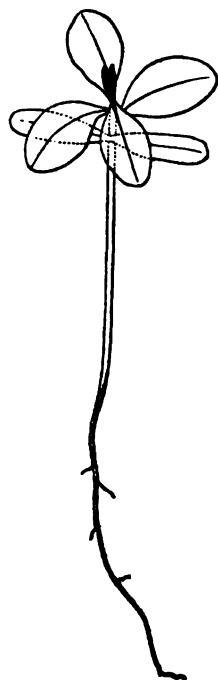


FIG. 689.  
*Buxus sempervirens*.  
Nat. size.

mottled with red, about 2 mm. long on the primary stem and 1 mm. long on the lateral branches.

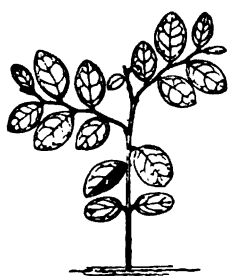


FIG. 640.  
*Phyllanthus flaccidus*.  
Half nat. size.

Nos. 1 and 2. Oval or subelliptic, obtuse at both ends.

Nos. 8-5. Reduced to small subulate, acute teeth, similar to the stipules in shape and size or nearly so, bearing in their axils horizontal, leafy branches.

Leaves on the lateral branches similar to the primary ones but smaller, oval or elliptic, obtuse.

*Petalostigma quadriloculare*, Müll. Arg.

*Hypocotyl* erect, terete, glabrous, light green, 3-5 mm. long.

*Cotyledons* oval, obtuse, entire, tapering at the base to the petiole, glabrous, dark green, paler beneath, 1.8-2 cm. long including the petiole, which is slightly hairy beneath, 9-11 mm. wide; midrib sending off numerous ascending veinlets as in the leaves.

*Stem* herbaceous, erect, terete, pubescent, light green; 1st internode 2 cm.; 2nd rather shorter, about 1-1.8 cm. long.

*Leaves* simple, entire, cauline, alternate, petiolate, with short hairy stipules, pubescent on both surfaces, oval to obovate, obtuse, light green, somewhat reflexed; midrib prominent with numerous ascending veinlets, 1.2-1.8 cm. long, 7-8 mm. wide.

*Hevea brasiliensis*, Müll. Arg.

*Ovary* of three carpels, three-celled, three-ovuled; ovules pendulous, anatropous; micropyle superior.

*Fruit* a capsule, large, splitting into two-valved cocci; epicarp rather fleshy; endocarp woody, thick.

*Seed* pendulous, anatropous, oblong or roundish, large, glabrous, obtusely angled on the ventral aspect in conformity with the inner angle of the fruit, convex on the back, marked with black dots and irregular blotches on a pale or dark brown or ashy ground; hilum oblong or elliptical, nearly superior on the ventral aspect; raphe ventral, lying in a furrow on the central or rather inner angle of the seed, longitudinal, separable from the testa; chalaza at the lower end of the seed; radicle superior, close to the micropyle which occupies the centre of the upper end; testa crustaceous or woody, tough or strong but breaking with a clean transverse fracture; tegmen soft, spongy, pale grey.

*Endosperm* abundant, fleshy, completely surrounding the



embryo, but thinnest at the sides, yellowish or creamy white, 8 mm. wide on the ventral and dorsal faces.

*Embryo* straight, large, colourless; cotyledons thin, slightly curved at the sides and running through almost the whole length of the seed, closely applied with their backs to the placenta, but so far apart internally (at least when dry) as to leave an ellipsoid hollow, 1 cm. wide and 4-4.5 mm. deep, oblong in outline, with a distinct midrib, trinerved for the lower two-thirds, and then alternately penninerved, obtuse or subtruncate at the apex, cordate at the base.

*Hevea Spruceana*, Müll.

*Arg.* (fig. 641).

*Primary root* very strong, long, and tapering downwards.

*Hypocotyl* very short, stout, subterranean, glabrous, pinkish and mottled with yellow.

*Cotyledons* very large and wide, petiolate, subterranean and remaining in the seed till they decay after absorbing the endosperm; petioles flattened above, convex on the back, dilated and semi-amplexicaul at the base, glabrous, green, of unequal lengths when the position of the seed during germination necessitates it for the convenience of exit of the plumule; the longer 10.5 mm. long; the shorter 7.5 mm.

*Stem* erect, subcompressed in the young state, glabrous, deep-dull green, soon becoming woody; 1st internode 12-20 cm.; 2nd about 8 mm. long.

*Leaves* compound, cauline, alternate (first two opposite), stipulate, petiolate, with the leaflets subsessile or narrowed to a very short petiolule, alternately incurvinerved, reticulate, entire, glabrous, somewhat shining or glossy, deep olive-green on the upper surface, suffused with a glaucous-purple beneath (at least when young); stipules small, subulate, acute, pale green, interpetiolar in the primary pair; petioles subterete, stout or dilated at the base, and tapering upwards, narrowly channelled on the upper surface, deep dull green, glabrous.

Nos. 1 and 2. Opposite, digitately trifoliate; leaflets oblong-



FIG. 641.—*Hevea Spruceana*.  
One-fourth nat. size.

lanceolate, acuminate, suddenly narrowed at the base into a short petiolule, but not articulated with the rachis, unequal; middle one longest and slightly the widest.

No. 8. Alternate, similar to the first two but apparently on a much smaller scale, and at the end of a very short internode.

### *Jatropha Curcas*, L.

*Ovary* of three carpels, three-celled, three-ovuled; ovules pendulous, anatropous; micropyle superior.

*Fruit* a capsule, ovoid, blunt at both ends, tipped with the persistent base of the style, with six shallow longitudinal furrows (at least when dry) denoting the dorsal and ventral sutures of the carpels, more or less reticulate, three-celled, three-seeded, falling away in two-valved, one-seeded cocci; endocarp hardened or woody.



FIG. 642.—*Jatropha Curcas*.  
Half nat. size.

*Seed* large, oblong, blunt at both ends, slightly dorsally compressed, and very obtusely subtrigonal, glabrous, brown, shallowly sculptured all over; testa crustaceous, generally thickest on the ventral aspect, and at each end; tegmen thicker, harder and pale brown; micropyle nearly or quite superior; hilum near the upper end on the ventral aspect and contiguous to the micropyle; raphe ventral; chalazae inferior, large, and thickened internally.

*Endosperm* copious, fleshy, white, nearly divided longitudinally into halves by the embryo.

*Embryo* straight, large, nearly equal in length and breadth to the endosperm, colourless; cotyledons large, flat, oblong, obtuse, deeply cordate at the base, palmately five-nerved and somewhat reticulate by branches from the main nerves, adhering to the endosperm which shrinks when dry, leaving a hollow space in the middle; radicle short, stout,

oblong, obtuse, almost surrounded by the auricles of the cotyledons, imbedded in the endosperm, close to the micropyle.

**Seedling (fig. 642).**

*Hypocotyl* erect, stout, succulent, glabrous, smooth, pale green, slightly tapering upwards from 8–9 mm. thick, 8·5 cm. long.

*Stem* stout, succulent, green, glabrous, shining; 1st internode 1·1 cm. long; 2nd 2·8 cm.; 3rd 6 mm.

*Cotyledons* roundish-oblong, obtuse, entire, or emarginate, subauricled at the base, palmately seven- to nine-nerved and reticulate, grass green above, paler beneath, glabrous, 6 cm. long and 5 cm. wide, petiolate; petiole 3·2 cm. long, dilating upwards to the lamina, grooved on the upper side, with a bud in one of the axils.

*Leaves* cauline, alternate, stipulate, petiolate, simple.

No. 1. Cordate-ovate, acuminate, distantly and irregularly dentate-serrate, with the serratures mucronate, palmately nine-nerved, grass green above and glabrous, except in the sinus which is slightly hairy, paler beneath, with very prominent nerves; petiole nearly terete or slightly flattened on the upper side towards the lamina, pale green, glabrous, 8·6 cm. long; stipules small, subulate, acute, almost filamentous.

No. 2. Cordate, acuminate, somewhat angled, but scarcely lobed, coarsely dentate, palmately nine-nerved; petiole terete, otherwise like the first.

No. 3. Similar to, but smaller than the second.

***Jatropha podagrica*, Hook. (fig. 643).**

*Hypocotyl* thickened upwards from 5 mm. at the base to 8 mm. near the apex, 7 cm. long.

*Cotyledons* broadly oblong, rounded at the apex, obsoletely auricled at the base, palmately trinerved, 3·1 cm. long, 2·2 cm. wide, glabrous and smooth; petiole 1·5 cm. long, semiterete, channelled on the upper side, red.

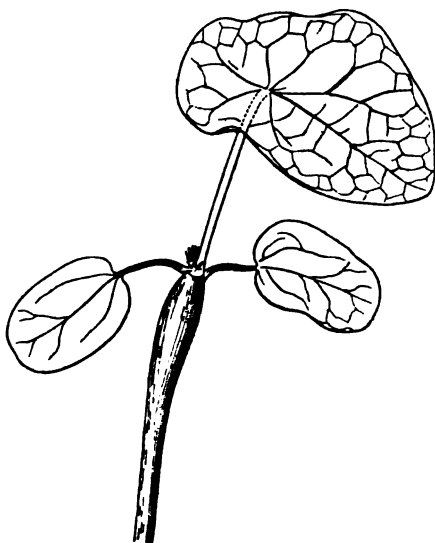


FIG. 643.—*Jatropha podagrica*.  
Half nat. size.

*Leaves* cauline, alternate, stipulate, petiolate, simple.

No. 1. Peltate, entire; lamina rotundly ovate in outline, obtuse, entire, radiately seven-nerved and reticulate, pale green above, deeply glaucous or whitish beneath, glabrous; petiole erect, terete, smooth, tapering from 8 mm. at the base to 2 mm. in thickness near the apex, 5 cm. long, pale green suffused with red on the basal half; stipules multifid, tipped with glands.

*Jatropha multifida*, L.

*Hypocotyl* woody and somewhat fleshy, erect, terete, glabrous, glaucous-green mottled with grey, varying in length from 9.5 cm. to more above the soil, stout, tapering from the base upwards.

*Cotyledons* large, fleshy, remaining in the seed till it is exhausted, when the whole becomes dry and drops away; petiole about 1.3 cm. long; lamina when removed from the dry seed 1.6 cm. long, 1.15 cm. wide.

*Stem* succulent, soon becoming woody, tapering upwards and more slender than the hypocotyl, deep green suffused with a glaucous bloom, and mottled with little white protuberances; 1st internode 1 cm. long; 2nd 3 mm.; 3rd 6.5 mm.; 4th undeveloped, bringing the third and fourth leaf opposite, but this is not a constant characteristic.

*Leaves* simple, digitate, cauline, alternate, stipulate, petiolate, intense green above with white or pale midribs to the primary and secondary segments, glaucous beneath with very prominent midribs, glabrous; petioles terete, glabrous, glaucous, tapering upwards from a stout base; stipules cut into slender, branching, bristle-like processes, pale green or colourless.

No. 1. Digitately seven-lobed; lobes lanceolate in outline, pinnatifid with irregular sized, subulate, acute, aristate segments; basal pair of lobes small with a large segment on the basal, anterior side; middle lobe somewhat deformed.

No. 2. Digitately nine-lobed; lobes lanceolate in outline, deeply and irregularly pinnatifid; basal lobes very small; ultimate segments subulate, attenuate, aristate.

Nos. 3 and 4. Digitately seven-lobed; lobes lanceolate in outline, tapering to both ends or lanceolate-elliptic; basal lobes with a large posterior and basal segment; ultimate segments subulate, attenuate or linear, and mostly aristate.

No. 5. Similar to three and four, but sometimes without large segments at the posterior and basal side of the basal lobes.

Ultimate leaves varying in size, and seven- to ten- or more lobed, with irregularly pinnatifid or pinnatipartite secondary divi-

sions, the longer of which are linear, acute, aristate; the shorter subulate.

***Mercurialis annua*, Müll. Arg.**

*Hypocotyl* erect, quadrangular, glabrous, 4–6 cm. long, light green or colourless.

*Cotyledons* ovate or subrotund, obtuse, entire, petiolate with rather long petioles, glabrous, light green, trinerved at the base with the midrib dividing into two branches near the centre of the leaf.

*Stem* erect, quadrangular, herbaceous, glabrous; 1st internode 5–6 mm. long; 2nd considerably shorter.

*First leaves* simple, cauline, opposite, decussate, petiolate, stipulate, ovate, acute, serrate or crenate, rather hairy, light green, distinctly pinnatinerved; stipules apparently persistent, small; petioles short, channelled on the upper side.

In two out of eight specimens there were three cotyledons, and the first leaves were verticillate in whorls of three.

***Acalypha virginica*, Müll. Arg.**

*Hypocotyl* erect, terete, minutely pubescent, 1.5–3 cm. long, light green or colourless, stained with red near the base.

*Cotyledons* orbicular, obtuse, slightly emarginate, petiolate, glabrous or with a few minute hairs on the edges and petioles, dark green, trinerved with the principal veins much branched.

*Stem* with primary internodes but slightly developed.

*First leaves* simple, cauline, opposite, ovate, obtuse, crenate-serrate, hairy, pinnatinerved, shortly petiolate, stipulate. Subsequent leaves alternate.

***Ricinus communis*, L.**

*Ovary* as in *Jatropha*.

*Fruit* dry, trilobed, three-seeded, breaking up into three two-valved cocci.

*Seed* ovoid-oblong, dorso-ventrally compressed, 1.5–1.65 cm. long, 9–10 mm. wide; testa crustaceous, shining, marked with deep shining brown on a grey ground; raphe ventral; chalaza at the base of the ventral aspect; micropyle superior, forming a large, white, emarginate process, separated from the rest of the seed by a constriction; hilum apical on the ventral aspect, almost concealed by the micropyle.

*Endosperm* abundant, fleshy or oily, white, surrounding the embryo.

*Embryo* straight, flat, very large, central, colourless; cotyledons broad, oblong, obtuse, falling a little short of the whole length of the seed, alternately penninerved and reticulate, slightly cordate at the base, adhering to the endosperm and separated from one another; radicle short, stout, oblong, obtuse, extending beyond the cotyledons for about half its length; plumule inconspicuous.

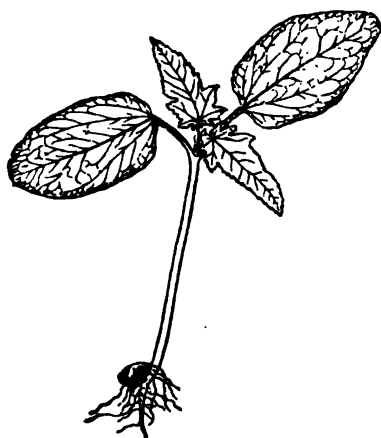


FIG. 644.—*Ricinus communis*.  
One-fourth nat. size.

#### Seedling (fig. 644).

*Primary root* a succulent taproot, not very long, with many thick, colourless, lateral rootlets.

*Hypocotyl* 10–15 cm. long, 3.5–5 mm. thick, succulent, terete, glabrous, reddish.

*Cotyledons* with a channelled, glabrous, glandular petiole 3 cm. long, 2.5 mm. broad, 1.5 mm. thick, and an entire lamina, oblong in one and ovate-oblong in the other, rounded or subcordate at the base, very obtuse at the apex, about 8 cm. long, 4–5 cm.

wide, palmatinerved at the base, glabrous, thinly succulent, bright green above, paler beneath. The disparity of the cotyledons is probably accidental in the specimen sketched.

*Stem* very short at first; 1st internode 5 mm. long, half as thick as the hypocotyl, slightly compressed, glabrous, dark green.

*Leaves* simple, cauline, alternate, with glandular stipules, petiolate, palmately seven- to many-nerved and -lobed especially at the base, with the lobes alternately nerved upwards, reticulated, serrate, glabrous, deep green above, paler beneath.

Nos. 1 and 2. About 6 cm. long at first by 3 cm. wide, palmatilobed at the base; terminal lobe about 4 cm. long by nearly 2 cm. wide, acuminate, subpeltate at first, but splitting at the base after some time so as to render it truly palmati-lobed and -nerved, obtusely serrate and mucronate, glabrous, fleshy but thin, bright green above, paler beneath.

#### *Dalechampia capensis*, *Spr. fil.* (fig. 645).

*Hypocotyl* 2.7 cm. long, 1–1.5 mm. thick, terete, with a short, spreading pubescence.

*Cotyledons* rotund or rhomboid, oblique, sometimes emarginate, undulated or twisted, and frequently very unequal at the base, palmately trinerved, with sometimes irregular secondary nerves, reticulate, pubescent, and somewhat scabrous above, glabrous below except on the nerves.

*Stem* terete or slightly angled on two sides, soft, densely covered with long and short spreading pubescence; 1st internode 1·5–3 cm. long; 2nd shorter.

*Leaves* opposite and alternate, cauline, stipulate, petiolate.

Nos. 1 and 2. Palmately three- to five-nerved, and coarsely serrate-dentate or lobed, with obtuse teeth ending in a minute mucro; lamina more or less triangular with a cordate base, pubescent above and on the nerves beneath, and having two short, cylindrical glands in the basal sinus; petiole terete, channelled above, hirsute, 8 mm. long; stipules contiguous, small, subulate, acute, patent, pubescent.

No. 3. Alternate, deeply trilobate, palmately five-nerved, cordate at the base, pubescent above and on the nerves beneath; lateral lobes oblong, oblique, obtuse, mucronate, distantly serrate along the posterior margin, with one to two teeth towards the apex on the anterior margin, irregularly penninerved; terminal lobe subelliptic, obtuse, mucronate, penninerved with two to three serratures on each side.



FIG. 645.  
*Dalechampia capensis*.  
Half nat. size.

## URTICACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 341.

*Fruit and Seed*.—The ovary is superior or more or less inferior in a few genera, and always consists of a single carpel, which is one-celled and one-ovuled, or the ovule is rarely accompanied by another, the growth of which however is soon arrested. It is inserted on a basal or nearly basal placenta, is erect or ascending, and orthotropous, very slightly amphitropous; sometimes it is inserted at or near the apex, and is

pendulous, anatropous or shortly amphitropous ; the micropyle is always superior. The fruit is one-seeded, indehiscent, and generally small, sometimes an achene and dry, fleshy or succulent, free or included in, or adnate to the perianth ; sometimes it is a drupe and free, or it consists of numerous carpels, immersed or sunk in a fleshy receptacle or surrounding the thalamus and densely aggregated or united, forming a compound fruit as in the Mulberry. The seed is erect, pendulous or laterally attached and conforms to the cavity of the fruit ; the testa is membranous or rarely crustaceous. Endosperm is wanting or forms a thin layer surrounding the embryo, and occupying its sinus in some cases when it is sometimes unilateral. The embryo is straight or curved, and fleshy with a short or minute, superior radicle. Sometimes the cotyledons are variously unequal, folded, or involute, with a superior radicle, or the latter is again curved downwards and incumbent.

Exceptional cases occur where endosperm is copious and fleshy, as in a few species of *Trema*, in *Parasponia*, in the tribe *Cannabineæ*, in *Morus*, *Bosquiea*, *Sceptrocnide*, *Parietaria*, *Urtica dioica*, *Cypholophus*, *Thelygonum*, and in a few species of other genera.

One of the simplest types of embryo is that occurring in *Parietaria officinalis*. The seed closely conforms to the ovoid fruit and contains a large quantity of endosperm surrounding the straight embryo, which has oval cotyledons, longer than the radicle. The achene of *Urtica dioica* (fig. 650) is ovoid and laterally compressed with a smaller quantity of endosperm surrounding the embryo. The cotyledons are orbicular, emarginate owing to a thickening at the chalaza, and longer than the radicle.

A distinct type occurs in *Cannabis sativa* where the achene is oval and the seed which conforms to it has a small quantity of endosperm between the radicle and the oval, plano-convex, incumbent cotyledons.

A still more complicated type is met with in *Celtis occidentalis*. The fruit is a somewhat fleshy drupe, one- or sometimes two-seeded, with a bony endocarp. The seed is campylotropous, inserted near the top of the cavity, and when two are present, they are collateral. The endosperm occupies a small space



on the ventral aspect of the seed in the folds of the embryo. The latter occupies the dorsal aspect round which it is curved with the radicle incurved and abutting with its tip against the ventral aspect. The cotyledons are broadly oblong, deeply emarginate or bifid at the apex, more or less folded transversely and also deeply infolded at the apex in order to accommodate themselves to the interior of the seed. The apical fission facilitates the folding. They are trinerved in the lower half, and while yet in the seed auricled at the base, but by subsequent growth they become cuneate.

A fourth type is met with in *Humulus*, which has a spirally coiled embryo. The seed is nearly globular, but slightly elongated at either end, and contains in *H. japonicus* a small quantity of endosperm alongside the tip of the radicle and a smaller portion in the centre of the coiled embryo. The radicle is terete and considerably elongated. The cotyledons are incumbent, and the inner has one coil more than the outer so that after germination they are of equal length. The outer one makes about two complete coils, and the inner one three coils. The seed of *H. Lupulus* is exalbuminous; the embryo is coiled in a similar way to the last. When spread out the cotyledons in both cases are linear and plano-convex, or more or less compressed in the middle according to the pressure to which the different portions are subjected.

*Seedlings*.—About seven different types of cotyledons have come under my observation. The simplest type occurs in *Conocephalus niveus* (fig. 649) which has very small, orbicular, petiolate cotyledons. The first pair of leaves are very small, ovate and entire; the second pair are roundly ovate and slightly toothed near the top and trinerved; the third pair are cordate-ovate, trinerved and serrate.

The cotyledons of *Urtica dioica* are somewhat larger than those of the last, rotund, emarginate, pubescent above, trinerved and petiolate. *Laportea urens* is somewhat similar but has larger cotyledons showing a midrib only. The first leaf is roundly ovate; the second much larger, cordate and inserted almost on the same level; the third is similar to the last but larger. The cotyledons of *Girardinia palmata* (fig. 651) are comparatively large, obovate-rotund, emarginate, trinerved

at the base with a second pair of strong nerves given off from the middle, and all the four laterals are incurved at their apices. The first two leaves are opposite, trinerved, ovate and serrate-dentate. The third and fourth are rotund-ovate; all are covered with coarse stinging hairs projecting at right angles to the surface. The cotyledons of *Dorstenia Contrajerva* (fig. 647) are rotund, emarginate, rarely oval, subtruncate at the base and trinerved. The primary leaves are cordate, trinerved, distantly dentate, and serrate. They show a tendency to become trifid; and the leaves of the adult are three- to five-lobed. A slight divergence from this type is shown by *Ficus bengalensis* (fig. 648) which has roundly ovate, emarginate and trinerved cotyledons close to the ground owing to the shortness of the hypocotyl. The first two leaves are opposite, ovate and obscurely crenate, while the third and fourth are alternate, and ovate with a cordate base.

A third type, represented by *Maclura aurantiaca*, has oblong-oval, entire and somewhat penninerved cotyledons. The two primary leaves are opposite, lanceolate, acuminate, obtuse and penninerved.

A rather distinct type occurs in *Celtis occidentalis* (fig. 646) which has oblong, deeply emarginate, trinerved cotyledons, cuneate at the base and tapering into a short petiole. The cause of the emargination has been described above as due to folding. In *Urtica dioica* (fig. 650) it was due to a thickening at the chalaza inside the seed, and is doubtless augmented by unequal growth subsequent to germination. Two of the primary leaves are opposite, ovate, trinerved, serrate and symmetrical at the base. The four succeeding ones are much larger and wider but otherwise similar. The ultimate leaves are unequal at the base, somewhat resembling those of the Elm.

The cotyledons of *Cannabis sativa* are unequal, obovate-spathulate, sessile and trinerved. The longer cotyledon varies from 1.4-1.6 cm. in length and 5-6 mm. in width, while the shorter one is 1-1.3 cm. long and 5.5-6 mm. wide. Their shape and inequality are due to their being incumbent in the seed. The larger one occupies the periphery of the seed and is curved, while the smaller lying between the long one

and the radicle has less space to develop. The first two leaves are opposite as in many previously mentioned species, lanceolate and serrate; but in vigorous seedlings a pair of lobes is developed at the base. The second pair are digitately tripartite with lanceolate, serrate divisions, the middle one of which is much the largest. The third and fourth pairs are digitately four- to five-partite with lanceolate segments; and the ultimate leaves have numerous lanceolate, acuminate, radiating segments. The cotyledons of *C. gigantea* are downy, but otherwise similar to those of *C. sativa*. The first two leaves are lanceolate-oblong, while the second pair are deeply tripartite at the base, with the terminal segment much the largest.

The cotyledons of *Girardinia heterophylla* differ from those of *Cannabis* in being relatively wider, emarginate, petiolate and alternately penninerved, and from *Urtica dioica* in shape, venation and their much greater size. The two primordial leaves are opposite, oblong and coarsely serrate. The cotyledons of *Forskohlea viridis* are relatively narrower than those of the last, and pubescent, but otherwise resemble them. The two first leaves are opposite, lanceolate and distantly serrate.

The seventh type is represented by *Humulus japonicus*, which has linear, obtuse, or acute cotyledons, slightly connate at the base, and showing a sunk midrib only. They are also finely glandular-pubescent, equal in length, and 2.8–3 cm. long by 2.5–3 mm. wide. The stipules are interpetiolar, and the two from adjoining leaves are connate into one blunt piece. The two first leaves are trifid, and the two following five-lobed and five-nerved.

### *Celtis occidentalis*, L.

*Pistil* syncarpous, superior; ovary one-celled, one-sometimes two-ovuled, surmounted by the deeply bi-fid or -partite style; ovules subapical, pendulous, campylotropous, collateral when two are present; radicle dorsal, superior, close to the apex of the cell, elongated.

*Fruit* a rather fleshy berry or drupe, ovoid, slightly oblique and tipped with the short, persistent, hardened base of the style, one-celled, one-sometimes two-seeded, deep green when young, becoming pale or yellowish ultimately slightly reddish, glabrous; mesocarp

rather fleshy, deep green, ultimately somewhat pulpy; endocarp bony, forming a smooth, hollow sphere, with which the seed conforms.

*Seed* suspended from one side slightly below the apex, globose with a prominent projecting micropyle close to or at the apex of the carpel, albuminous; testa thin, white when young or immature, marked with a semitransparent spot on the opposite side of the hilum from the radicle; hilum small, orbicular, somewhat prominent.

*Endosperm* fleshy, white, originally occupying the whole seed, but as the ovary grows becoming more and more pushed towards the hilum of the fruit with a considerable mass in the concave face or hollow formed by the cotyledons.

*Embryo* fleshy, colourless, straight at first, then becoming concave on the side towards the placenta, and increasing till it attains the length of the fruit; the ends of the cotyledons then curve up the other side of the seed towards the hilum, the apical halves become folded upon each other longitudinally, and the tips sometimes transversely folded; the cotyledons also become emarginate at a very early age, when they are shortly oblong, rounded at the base, subsequently elongating and becoming obovate-oblong, deeply emarginate or bifid, cordate at the base and trinerved, with the midrib forking close to the sinus, one branch entering each lobe of the cotyledon.

### **Seedling (fig. 646).**

*Primary root* long, tapering, flexuose, and giving off numerous rootlets.

*Hypocotyl* woody, erect, terete, pubescent, pale green, about 4 cm. long.

*Cotyledons* oblong, deeply emarginate, cuneate at the base, shortly petiolate, three- or obscurely five-nerved from the base with the midrib forking and one fork going to each of the apical lobes, minutely pubescent, deep green above, paler beneath, 1.7 cm. long including the petiole, 7 mm. wide.

*Stem* woody, erect, terete, hispid and pale green, ultimately forming a large tree; 1st internode 9–13 mm. long; 2nd 1.4 cm.

*Leaves* simple, cauline, alternate (first two opposite), stipulate, petiolate, coarsely hairy and pubescent or hispid, ultimately glabrous or nearly so, alternately penninerved and reticulate, plicate in vernal condition, and covered in the young unfolding condition with clear, crystalline, dot-like glands pellucid in the seedling plant owing to the thinness of the leaves; petiole short, terete, hairy, articulated

with the stem; stipules oblong-subulate, hairy, hyaline, caducous, sometimes though rarely half-ovate, subfoliaceous, somewhat persistent in the adult tree.

Nos. 1 and 2. Opposite, ovate, acuminate, coarsely serrate, trinerved in the lower half, with the small stipules parallel and in close contiguity, equal at the base.

Nos. 3 and 4. Similar, but larger.

No. 5. Somewhat unequal at the base, otherwise like the rest, cut away on the posterior basal side.

The fruit and seedling of *Celtis australis*, L., are described by Tubeuf (l. c. pp. 54 and 115). They are very similar to those of *C. occidentalis*, but the cotyledons of *C. australis* are wider and rhomboidal in shape with a shallower emargination. The first pair of leaves are similarly longer and narrower and acuminate.

Tubeuf also figures and describes (p. 58) fruits of several species of *Ulmus*, and also a seedling typical for the genus (p. 115). He says: 'The cotyledons resemble in shape those of *Carpinus Betulus*; they are obovate, petiolate, with two basal auricles 1·7 cm. long (not including the petiole) and almost as wide; they are thick, fleshy, green above, whitish beneath, with a venation not at all or with difficulty discernible, and are slightly hairy above with an entire margin. The first leaves are almost sessile, alternate, show a midrib and side nerves, are coarsely hairy like the stem, coarsely serrate, and acute.'

### *Humulus Lupulus*, L.

*Pistil* syncarpous, superior; ovary one-celled, one-ovuled, surmounted by the short style and two linear stigmas; ovule pendulous, campylotropous, attached to the apex of the cell; micro-pyle superior, close to the hilum.

*Fruit* an achene, broadly ovoid, compressed antero-posteriorly, in the axil of an accrescent bract which folds over it with one oblique

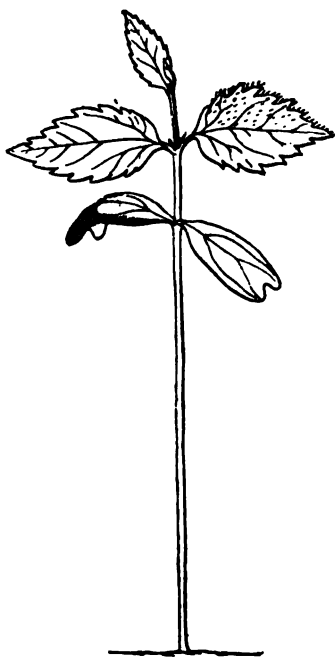


FIG. 646.—*Celtis occidentalis*.  
Nat. size.

basal side, covered except at the tip with yellow granulose, viscid, highly odorous glands, purplish and finely netted before maturity, afterwards pale brown or grey, sometimes tipped by the two stigmas when nearly mature.

*Seed* pendulous from the top of the fruit, subobovoid, slightly compressed, with a ridge containing the radicle running along the side opposite to the raphe, pale brown, smooth, somewhat shining, exalbuminous; hilum raised and somewhat prominent on one edge of the seed, a deeper brown than the rest; testa brittle; tegmen greenish and subfleshy, marked by the coils of the embryo and deeply impressed by the radicle.

*Embryo* in the mature seed spirally twisted and occupying the whole interior, fleshy and colourless; cotyledons incumbent, spirally rolled over one another with their edges towards the edges of the seed and surmounted by the cylindrical, obtuse radicle, linear, obtuse, slightly narrowed to the base, 4.5 mm. long, 1 mm. wide at the apex; radicle 2 mm. long.

*Humulus japonicus*, Sieb. et Zucc.

*Achene* with thin membranous pericarp, and thicker endocarp, globose.

*Seed* globose, conforming to the shape of the achene, slightly flattened, 4-4.25 mm. in diameter; testa hard, crustaceous; tegmen almost imperceptible, smooth; hilum inconspicuous.

*Endosperm* reduced to a fine film surrounding the embryo, greenish.

*Embryo* spirally coiled, colourless, filling nearly the whole seed; cotyledons as in *H. Lupulus*; radicle terete, obtuse, incumbent on the back of the cotyledons and about as long.

### Seedling.

*Primary root* tapering gradually downwards, and giving off fibrous lateral rootlets.

*Hypocotyl* erect, terete, glabrous, reddish, 3-6.25 cm. long, and more or less tinted with red.

*Cotyledons* linear, entire, obtuse or acute, slightly connate at the base, very shortly and finely pubescent with hairs which become glandular when fully developed, with a distinct midrib sunk on the upper surface, and prominent beneath, 2.8-3 cm. long and 2.5-3 mm. wide.

*Stem* ultimately twining round some support, with the internodes undeveloped in the seedling stage.

*Leaves* simple, cauline, opposite, stipulate, petiolate, hairy and

glandular ; stipules of each pair interpetiolar and connate into one blunt or truncate piece ; petiole semiterete, channelled on the upper surface.

First pair tri-fid or -lobed.

Second pair palmately five-nerved and -lobed.

***Cannabis sativa*, L.**

*Fruit* an achene.

*Seeds* orbicular or oval, 1·5–2 mm. in diameter ; testa smooth, greenish-brown ; hilum inconspicuous.

*Endosperm* thin, surrounded by the embryo, fleshy, greyish-white.

*Embryo* curved or rounded on itself, surrounding the endosperm, colourless ; cotyledons oval, obtuse, plano-convex, closely adpressed ; radicle terete, obtuse, lying close to the hilum, superior, slightly longer than the cotyledons.

### Seedling.

*Primary root* tapering downwards, flexuose, fibrous.

*Hypocotyl* erect, terete, pubescent, soon becoming firm and woody, 3–5 cm. long.

*Cotyledons* unequal, obovate-spathulate, tapering downwards, blunt, sessile and slightly connate at the base, erect for some way above the base and then recurved, pubescent on the upper surface, with a distinct midrib and two lateral nerves arising from the base, which unite with other two nerves arising about the middle of the cotyledon and run to the apex ; longer cotyledon 1·4–1·6 cm. long, 5–6 mm. wide ; shorter one 1–1·3 cm. long, 5·5–6 mm. wide.

*Stem* erect, terete, striated, hairy, herbaceous or subwoody ; 1st internode 1·8–2·5 cm. long ; 2nd longer.

*Leaves* simple, digitate (first pair merely serrated), cauline, opposite, stipulate, petiolate, distinctly penninerved with ascending nerves, hairy on the upper surface and on the nerves beneath ; stipules small, subulate or linear, acute, slightly hairy ; petioles semiterete, hairy, channelled above.

First pair lanceolate, obtuse, bluntly serrate, sometimes with two lateral lobes at the base.

Second pair digitately tripartite, with lanceolate obtuse and obtusely serrated segments ; terminal segment much the largest.

Third pair digitately four- or five-partite with lanceolate acuminate segments.

Fourth pair digitately five-partite.

***Maclura aurantiaca*, Nutt.**

*Hypocotyl* erect, terete, glabrous, 4-5 cm. long, light green.

*Cotyledons* rather fleshy, oblong-oval, obtuse, entire, shortly petiolate, glabrous, shiny, dark green above, paler beneath, pinnatinerved like the leaves.<sup>1</sup>

*Stem* erect, terete, herbaceous, ultimately woody, covered with stout hairs; 1st internode 8-12 mm. long.

*First leaves* simple, entire, cauline, opposite, lanceolate, acuminate, acute, covered with minute hairs, light green, pinnatinerved; petioles short, channelled, hairy; stipules small, deciduous.

***Dorstenia Contrajerva*, L. (fig. 647).**

*Hypocotyl* erect, terete, pale green, 6-10 mm. long, pubescent.

*Cotyledons* rotund, rarely oval, emarginate, subtruncate at the base, trinerved, glabrous, variable in size, 5.5-9 mm. long, 7-9.5 mm. wide; petiole slightly channelled above, pubescent, 3-4 mm. long.

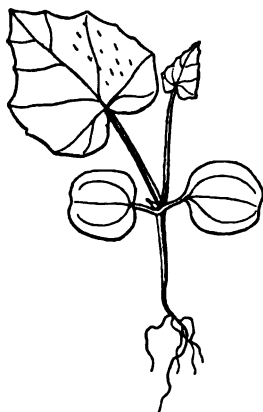


FIG. 647.  
*Dorstenia Contrajerva*.  
Nat. size.

*Stem* herbaceous, stout, fleshy, very short with scarcely developed internodes, forming a perennial rootstock.

*Leaves* simple, cauline, alternate, stipulate, petiolate, deep green above, thinly hairy, paler beneath and pubescent especially on the nerves, five-nerved on the basal half and alternately nerved upwards; petioles pubescent, terete and channelled towards the apex; stipules subulate, obtuse, green, pubescent.

No. 1. Cordate, subacute, five- to seven-angled, and five-nerved, thinly and obscurely dentate between the angles.

No. 2. More decidedly angled and dentate.

Ultimate leaves deeply trilobed; middle lobe rhomboid or triangular-ovate, acuminate, strongly trinerved and reticulate, with an angle or shallow lobe about the middle on each side, and obscurely dentate along the margins; lateral lobes obliquely ovate, acute, strongly binerved and reticulate, with one of the nerves running into a small lobe on the oblique side.

<sup>1</sup> Tubenf, l. c. p. 114, describes the cotyledons as roundly-elliptic, and from 1.7 cm. long.



***Ficus bengalensis*, L. (fig. 648).**

*Hypocotyl* erect, terete, minutely pubescent, or papillose, pale green, 3–4 mm. above the soil.

*Cotyledons* broadly ovate, obtuse, emarginate, petiolate, glabrous, deep green above, paler beneath, with an indistinct midrib and one to two nerves on each side; lamina 3.5–4 mm. long, 2.75–3 mm. wide; petiole flattened above, dilated and slightly connate at the base, 1–1.25 mm. long.

*Stem* erect, terete, minutely pubescent or papillose, pale green, ultimately woody; 1st internode .5–2.5 mm. long; 2nd .5–1.5 mm.

*Leaves* simple, cauline, alternate (first two opposite), stipulate, petiolate, alternately or sometimes, especially at the base, oppositely incurvinnerved, glabrous, somewhat shining on both surfaces, deep green above, paler beneath, evergreen, ultimately coriaceous; stipules erect, small, subulate, acute, pale green; petioles semiterete, channelled above, slightly tapering upwards, glabrous or minutely papillose on the upper edges, at least when young.

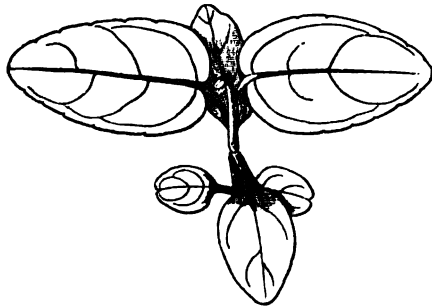


FIG. 648.—*Ficus bengalensis*,  $\times 2$ .

Nos. 1 and 2. Opposite, ovate, obtuse, slightly cuneate at the base, obsoletely crenate or almost entire.

Nos. 3 and 4. Alternate, ovate, obtuse, shallowly cordate at the base, very shallowly crenate.

Tubeuf (l. c. p. 58) describes fruit and seed of *Morus alba* (the Mulberry), and (p. 114) also figures and describes the seedling. The embryo lies curved in the albuminous seed. The cotyledons remain in the testa till they have absorbed the endosperm; they are 8–9 mm. long, dark green above, lighter beneath, taper gradually into the short petiole, and have a faint venation consisting of a midrib with a few side nerves. The first leaves are irregularly dentate, have a midrib with lateral nerves, and including the petiole are slightly hairy.

***Conocephalus niveus*, Wight (fig. 649).**

*Hypocotyl* 1 cm. long, 1.5 mm. thick, terete, herbaceous, pale green, pubescent.

*Cotyledons* petiolate, pubescent; lamina rotund, 2 mm. long, thin, or almost membranous; petiole 1.5 mm. long, slender.

*Stem* erect, terete, herbaceous, pubescent and hairy, pale green, about 2 mm. thick; 1st internode 4 mm. long; 2nd 9 mm.; 3rd 1.1 cm.

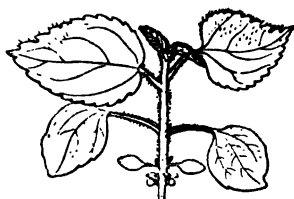


FIG. 649.—*Conocephalus niveus*.  
Half nat. size.

*Leaves* cauline, opposite, decussate, exstipulate, petiolate, pubescent, and coarsely hairy on the younger leaves; less hairy on older ones.

First pair small, ovate, obtuse, entire; petiole slender, semiterete, 3–4 mm. long.

Second pair much larger; rotund-ovate, obtuse, palmately trinerved, absoletely and distantly serrate; petiole semiterete, channelled above, closely pubescent, and sparsely hairy.

Third pair scarcely opposite, cordate-ovate, acute, coarsely serrate; nerves ascending and incurved; serratures subtriangular.

### *Urtica dioica*, L. (fig. 650).

*Pistil* apocarpous, superior; ovary of one carpel, one-celled, one-ovuled; ovule basal, erect, orthotropous; micropyle superior.

*Fruit* an achene, ovate, compressed, glabrous, included in the somewhat accrescent perianth, tipped by the persistent base of the style, subancipitous, straw-coloured; pericarp subcrustaceous.

*Seed* ovate, compressed, closely conforming to the interior of the achene; testa thin, membranous, closely applied to the interior of the pericarp; micropyle apical, and superior; hilum and chalaza basal, the latter dark-coloured and rather prominent, causing an emargination in the endosperm and cotyledons.

*Endosperm* forming a thin layer round the embryo, subfarinaeous, white.

*Embryo* central, straight, large, nearly equalling the length and breadth of the seed, colourless; cotyledons rotund, obtuse or minutely emarginate with a small rounded or obtuse tooth in the notch, subtruncate at the base; radicle oblong, terete, obtuse, pointing to the micropyle close to the apex of the seed, somewhat shorter than the cotyledons.

### Seedling.

*Primary root* slender, tapering, with fibrous lateral rootlets.

*Hypocotyl* succulent, terminating abruptly at the lower extremity, slightly pubescent, pale green, mottled with red, 1.1 cm. long.

*Cotyledons* rotund, emarginate, pubescent on the upper surface, glabrous beneath; lamina 4 mm. long, 4.5 mm. wide; petiole long slender, channelled above, slightly pubescent, pale green or transparent, 4 mm. long.

*Stem* herbaceous, erect, ridged and furrowed, pubescent with short deflexed and bulbous-rooted, stinging hairs, pale green or stained purple on the ridges; 1st and 2nd internodes each 1.5 cm. long.

*Leaves* simple, cauline, opposite, decussate, stipulate, petiolate,

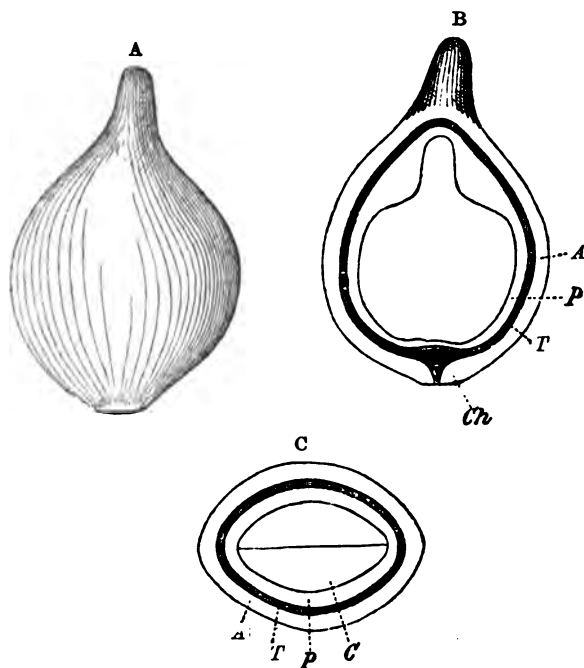


FIG. 650.—*Urtica dioica*. A, achene,  $\times 80$ . B, longitudinal section of achene,  $\times 80$ : Ch, chalaza; T, testa; P, endosperm; A, pericarp. C, transverse section of achene,  $\times 80$ : A, pericarp; T, testa; P, endosperm; C, cotyledon.

pubescent on both surfaces, and, like the stem, more or less abundantly furnished with bulbous-rooted stinging hairs on both surfaces, five-nerved at the base, and alternately penninerved upwards; nerves incurving, reticulate; petioles subterete, narrowly channelled above, and shallowly ridged and furrowed on the back, pubescent, and usually bristly with stinging hairs; stipules small, subulate, acute, subciliate in the seedling plant, ovate-oblong, obtuse, trinerved, ciliate, and pubescent in the adult.

First pair small, broadly ovate, obtuse, coarsely serrate, trinerved at the base.

Second pair triangular, obtuse, coarsely serrate, five-nerved at the base.

Third pair cordate, obtuse or subacute, five-nerved at the base, coarsely and obtusely serrate; serratures frequently aristate.

Ultimate leaves cordate, acuminate, acute, with acute or subacute serratures; nerves sunk above, prominent beneath.

***Girardinia palmata*, Wedd. (fig. 651).**

*Hypocotyl* erect, terete, minutely and finely pubescent, pale green, 2-3 cm. above the soil.

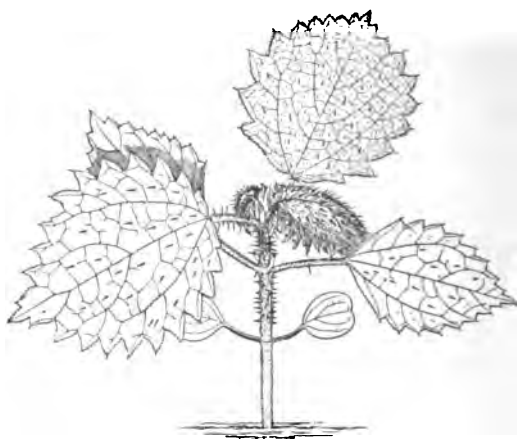


FIG. 651.—*Girardinia palmata*. Half nat. size.

*Cotyledons* rather large, obovate-rotund, emarginate, suddenly tapered into the petiole, trinerved, the lower nerves springing from near the base of the lamina, describing an intramarginal curve, and uniting with the next pair, which in turn meet the midrib below the thickened apex close to the apical notch, glabrous, light green; lamina about 1.3 cm. long, 1.2 cm. wide; petiole slender, semi-terete, channelled above, minutely pubescent, 8-10 mm. long.

*Stem* erect, terete, finely pubescent and furnished with coarse, stinging barbs, or hairs; 1st internode 1.9 cm. long; 2nd undeveloped; 3rd 7.5 mm.; 4th 3 mm.

*Leaves* simple, coarsely toothed and lobed, cauline, alternate (first two opposite), stipulate, petiolate, trinerved from the base, alternately nerved upwards and reticulate, hairy on both surfaces,

and furnished with coarse, bulbous-rooted, stinging hairs projecting at right angles from both surfaces of the leaf; petiole semiterete, shallowly channelled above, pubescent with rather fine, ascending or subadpressed hairs, and frequently well provided with large stinging hairs; stipules intrapetiolar, erect, connate into one acute binerved piece, pale-coloured or almost scarious.

Nos. 1 and 2. Opposite, ovate, acute, trinerved, obtusely serrate-dentate, the teeth tipped with a hair; the strong lateral nerves become incurved upwards, and run obliquely into the teeth, giving off lateral branches into adjoining teeth.

Nos. 3 and 4. Alternate, rotund-ovate, cordate at the base, more deeply and coarsely serrate-dentate than the first two, with a similar venation.

Nos. 5 and 6. Deeply incised or lobulate with the lower lobes again toothed. Venation as in those above.

***Girardinia heterophylla*, Dcne.**

*Hypocotyl* erect, striated, 1-1.5 cm. long, glabrous, light green or colourless.

*Cotyledons* obovate or subrotund, obtuse, emarginate, subfleshy, petiolate, glabrous, green, pinnatinerved like the leaves.

*Stem* short, erect, quadrangular, hairy; 1st internode 3-5 mm. long.

*First leaves* simple, cauline, opposite, decussate, oblong, coarsely serrate, subacute, hairy, and also covered with stings, green, pinnatinerved; petioles short, channelled above; stipules small, deciduous.

***Parietaria officinalis*, L.**

*Pistil* syncarpous, superior; ovary of two carpels, one-ovuled; ovule erect, orthotropous; micropyle superior.

*Fruit* an achene; pericarp hard, crustaceous, shining; seed conforming in shape to the achene, oval, oblong or obovate; testa smooth, membranous; hilum inconspicuous.

*Endosperm* comparatively copious, fleshy, surrounding the embryo, greyish-white or almost colourless.

*Embryo* straight, in the centre of the endosperm; cotyledons broadly oblong, or oval, obtuse, entire, plano-convex, lying with their apices to the receptacle; radicle terete, obtuse, about the same length as the cotyledons.

***Forskohlea viridis*, Ehrenb.**

*Hypocotyl* erect, terete, finely pubescent, 1-1.5 cm. long, light green, faintly tinged with red.

*Cotyledons* oblong-obovate, minutely emarginate, finely pubescent, light green with reddish petioles, pinnatinerved like the leaves.

*Stem* erect, terete, herbaceous, finely pubescent; 1st internode 8-7 mm. long.

*First leaves* simple, cauline, opposite, oblong, obtuse, dentate-serrate, petiolate, stipulate, finely pubescent, light green, pinnatinerved.

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## PLATANACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 396.

*Fruit and Seed.*—The ovary is linear, one-celled and one-ovuled with the wall greatly thickened on one side. The ovule is solitary, rarely are there two, one of which becomes aborted, pendulous from the apex of the cavity and orthotropous. This arrangement is very rare, as in dicotyledonous plants the ovule when single and orthotropous is in almost all other cases erect, the result of which seems to be to facilitate the easy access of the pollen-tube to the micropyle. The achenes are linear, surrounded at the base by long brown hairs, greatly thickened or clubbed in the upper part, and surmounted obliquely or on one side by the persistent remains of the style. The seed is solitary, pendulous, and linear with a membranous testa. Endosperm is usually present in small quantity surrounding the embryo, but is said to be sometimes absent. The embryo completely fills the remainder of the cavity, and is straight and linear. The cotyledons are plano-convex, very little wider than the inferior radicle and about equal to it in length or slightly longer. They generally lie in the broader plane of the seed with their edges towards the thickened portion, but are sometimes oblique to it.

The Order is represented by the single genus *Platanus*, consisting of five to six species. The above characters are well seen in longitudinal and transverse sections of the achene of a species of *Platanus*, probably *P. orientalis* (fig. 652).

*Seedlings.*—The seedling of *P. orientalis* (fig. 653) is comparatively small in conformity with the seed, but rapidly gains

strength as growth proceeds. The slender hypocotyl rises about 1.1 cm. above the soil, and is surmounted by narrowly spathulate, obtuse, one-nerved, sessile cotyledons tapering to a very narrow base. They are 8.5 mm. long and about 2.5 mm. wide at the apex. The first leaf is small, glandular-pubescent, and resembles a petiole. The second one is spathulate-cuneate, incipiently trifid or bluntly tridentate at the apex, and alternately penninerved, with two of the stronger nerves running into the teeth, thus foreshadowing lobing. The third leaf is much larger, but otherwise similar. The ultimate leaf is palmately five-nerved and -lobed; but the nerves for the lower pair of lobes often arise from the middle pair near the base.

*Platanus orientalis*, L. (fig. 652).

*Pistil* superior; ovary of one perfect carpel, one-celled, one- to two-ovuled; ovule pendulous from the top of the cell, orthotropous; radicle inferior.

*Fruit* an achene, one-celled and one-seeded, thickened and woody along one side, surrounded at the base by numerous, long, pale brownish, erect hairs, topped by a large woody process or callus which is surmounted by the persistent remains of the style.

*Seed* linear-clavate, suspended with the thick end uppermost, flattened on the side next the thickened portion of the pericarp; testa prolonged at the apex into an acute colourless point, and at the base into a colourless, blunt point, otherwise brown, easily broken up longitudinally into fibrous shreds; micropyle at the lower blunt end.

*Endosperm* forming a thin layer surrounding the embryo on all sides, whitish internally, brown externally.

*Embryo* straight, in the centre of the endosperm, colourless,

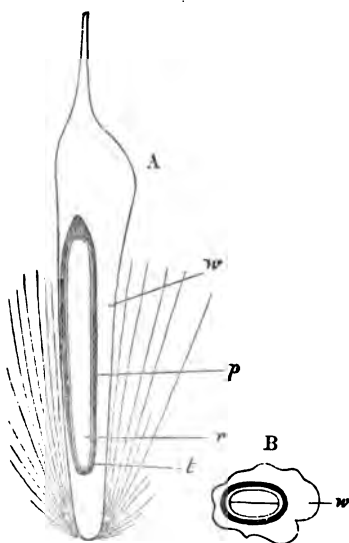


FIG. 652.—*Platanus orientalis*. A, longitudinal section of fruit,  $\times 6$ : w, woody part; p, endosperm; r, radicle; t, testa. B, transverse section of fruit: w, woody part,  $\times 12$ .

about 5.25 mm. long; cotyledons linear, suddenly pointed, subacute, a little longer and slightly broader than the radicle; radicle cylindrical, obtuse, at the opposite end of the seed from the hilum.

**Seedling (fig. 658).**

*Hypocotyl* erect, terete, slender, pale green, glabrous, about 1.1 cm. above the soil.

*Cotyledons* narrowly spathulate, obtuse, entire, tapered to the base, glabrous, opaque-green, distinctly one-nerved, 8.5 mm. long, 2.5 mm. at the widest.

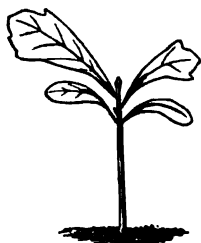


FIG. 658.  
*Platanus orientalis*.  
Nat. size.

*Stem* woody, erect, terete, glabrous or slightly glandular below the leaves; 1st internode about .5 mm. long; 2nd and 3rd each about 1 mm.

*Leaves* simple, cauline, alternate, stipulate, petiolate, glandular-pubescent at the margins and midrib (in young specimens); petioles channelled above; stipules small in the seedling, surrounding the base of the petiole, to which they are adnate, but in the adult stage of the tree they are of considerable size, cup-like and deciduous.

No. 1. Reduced to a short petiole, and glandular-pubescent.

No. 2. Spathulate-cuneate, bluntly tridentate at the upper end, alternately penninerved, with the nerves ascending and the larger ones running directly into the teeth.

No. 3. Similar but larger.

In *Platanus occidentalis*, *L.*, the cotyledons are narrow, lanceolate with a prominent midrib, 1.2 cm. long, 2 mm. wide, acute, sessile, and shining green above.<sup>1</sup>

The first leaves are alternate, entire, elongated-oval, serrate with shortly pointed teeth, with midrib and lateral nerves.

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## JUGLANDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 397.

*Fruit and Seed.*—The ovary is inferior and one-celled with a solitary, basal, erect, orthotropous ovule. The fruit is drupaceous or rarely nut-like and dry, sometimes with the

<sup>1</sup> *Vide* Tineuf, l. c., p. 116, fig. 153.



bract and bracteoles enlarged at its base, or partly or wholly adnate to its sides or even carried to the top forming an involucre; in other cases these organs remain unchanged and fall away. The exocarp is fleshy or succulent, generally falling away when mature, leaving the bony endocarp which is variously excavated into two or four cavities internally. The seed is two- to four-lobed at the base and lies astride the placenta with its lobes passing down into the cavities of the endocarp. Endosperm is wanting, and the embryo conforms to the interior of the seed. The cotyledons are fleshy and crumpled, or sometimes foliaceous and much folded and twisted, and the radicle is superior.

I have already described and figured the seed and seedling

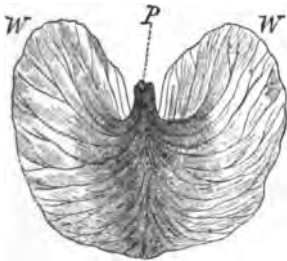


FIG. 654.—Fruit of *Pterocarya*,  $\times 2$ :  
P, perianth; W, W, wings.

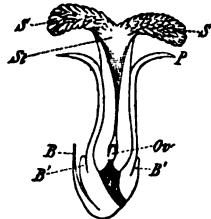


FIG. 655.—Longitudinal section through the flower of *Pterocarya caucasica*,  $\times 6$ :  
B, bract; B', B', bracteoles; Ov, ovule;  
P, perianth; St, style; S, S, stigmas.  
May 28.

of *Pterocarya caucasica*,<sup>1</sup> which are very peculiar. I have to thank Mr. Lynch for his kindness in keeping me supplied with specimens of the fruit in its various stages from the tree in the Cambridge Botanic Gardens. The seed<sup>2</sup> is shaped somewhat like an anvil, with four short, wide legs; and the seedling is remarkable in having the cotyledons bifid, each division being again bilobed.

*Pterocarya caucasica* flowers with us early in May. The pistil is syncarpous and inferior; the ovary of two carpels, one-celled, one-ovuled; the ovule basal, erect, and orthotropous.

Fig. 655 is a section through the young flower at the end of May, showing a bract B at the base, two bracteoles B' B' at the

<sup>1</sup> *Journ. Linn. Soc. Bot.* vols. xxii. and xxviii.

<sup>2</sup> *Ibid.* vol. xxii. p. 386, fig. 118.

sides, the ovule *Ov*, perianth *P*, and *SS* the two large, spreading, papillose stigmas. The cavity of the ovary is small and nearly filled by the ovule.

By about the middle of June the young fruit has grown considerably in thickness, though not much in length. The ovary and ovule are longer, and at the base of the former the tissue has in two places (fig. 656, *Co*, *Co*) become almost colourless from the removal of the protoplasm.

By the end of June the fruit has still further increased in length as well as in breadth. The growth in length has especially taken place between the base and the uppermost

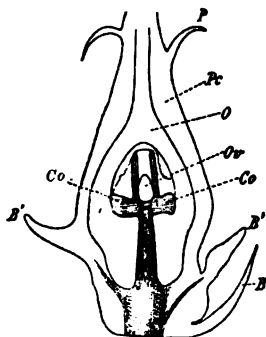


FIG. 656.—*Pterocarya caucasica*. Longitudinal section of fruit,  $\times 6$ . June 25. *Co*, *Co*, two places where the tissue has become colourless. (Other letters as in fig. 655.)

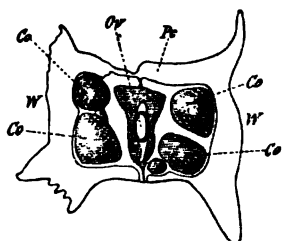


FIG. 657.—*Pterocarya caucasica*. Transverse section of fruit,  $\times 8$ : *W*, *W*, wings; *Pc*, pericarp; *Co*, *Co*, *Co*, *Co*, four spaces of altered tissue; *Ov*, ovule. (Other letters as in fig. 655.)

point of attachment of the bracteoles, which therefore seem to have been carried up. The bracteoles have also increased in size, while the perianth remains unaltered. The two masses of colourless tissue as seen in longitudinal section at the base of the ovary are still solid or unbroken.

The fruit continues to grow rapidly, especially at the base, so that by the end of July the posterior half of the bracteoles seems to be carried still further up, distinctly more so than the anterior. The neck of the fruit, on the contrary, has increased considerably in thickness, but scarcely at all in length. Fig. 657 represents a transverse section, and on each side of the ovule (*Co*, *Co*, *Co*, *Co*) are the four approximately circular

patches of colourless tissue, which in a longitudinal section appear more elongated. In them the tissue is commencing to disintegrate, while round them, on the contrary, it is becoming distinctly sclerenchymatous. From the development of the lower part of the fruit, especially on the posterior side, the posterior portion of each bracteole appears to be nearly on the summit of the fruit, the anterior portion being rather lower down.

Fig. 658 is a longitudinal section taken on August 8. It passes through two of the masses of loose tissue mentioned above, which now form cavities; while, on the other hand, the surrounding tissues have become much denser, leaving,

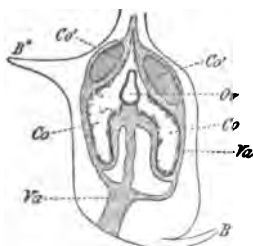


FIG. 658.—*Pterocarya caucasica*,  $\times 8$ : *Va*, *Va*, vascular tissue; *Co*', *Co*', masses of solid cortical tissue; *Co*, *Co*, cavities.

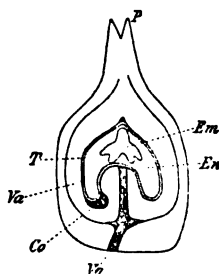


FIG. 659.—*Pterocarya caucasica*. Longitudinal section of more advanced fruit,  $\times 8$ . Sept. 1. *T*, testa; *En*, endosperm; *Em*, embryo; *P*, perianth; *Va*, vascular tissue; *Co*, small cavity not yet filled by the seed.

however, oval spaces of cortical tissue shown in section at *Co*', *Co*'.

The ovary has not materially altered, and the ovule is still very small.

A few days later, however, the ovule has grown considerably and nearly fills the cavities. Fig. 659 shows a longitudinal section taken on September 1. *T* is the testa, showing that the seed has now assumed its four-lobed form, though it has not yet quite filled the cavities in the fruit. The greater part, however, is occupied by endosperm, the embryo (*Em*) being still comparatively small.

Fig. 660 represents a transverse section near the base of the fruit, taken on September 21, when the fruit and embryo had

attained nearly their full size, but had not yet reached maturity. Neither the placenta nor the original and true cavity of the ovary are shown in this section, because they were situated at a higher level. The ovule from the first was basal, and the seed, even at maturity, may be looked upon as lying astride the basal placenta, with its four lobes projecting into as many cavities excavated from the originally solid base of the fruit. The testa is shown at *T*, lining the interior of the cavities and enclosing the variously folded lobes of the cotyledons (*C, C, C, C*). The walls surrounding the cavities are thick and sclerenchymatous, with exception of the thin outer rind

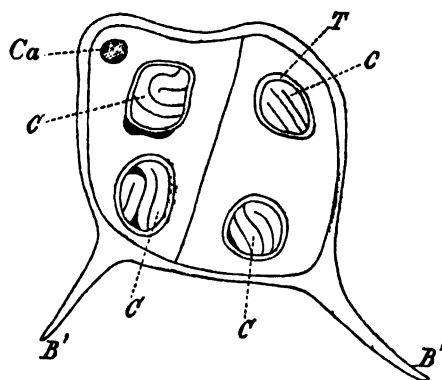


FIG. 680.—*Pterocarya caucasica*. Transverse section through a more advanced fruit near the base,  $\times 6$ . (Sept. 21.) *T*, testa; *C, C, C, C*, folds of cotyledons; *B, B'*, bracteoles or wings; *Ca*, small mass of cortical tissue.

and its appendages, the bracteoles or wings, shown at *B', B'*. The cotyledons of the embryo diverge, one to each side of the fruit, and their lobes pass in pairs into each of its four cavities. As growth proceeds and the short lobes become too wide for the cavities, they become conduplicate in order to accommodate themselves to the restricted space and at the same

time to fill it. The secondary fission seems intended to facilitate folding, and was probably originally brought about by excessive plication. If the two lobes had been in one piece, the latter would have had to be twice conduplicate longitudinally, which would have been difficult to accomplish. The folding is not always on the same plan, as may be seen by reference to the figure.

*The Walnut (Juglans).*—The fruit of the Walnut differs from that of *Pterocarya* in several remarkable particulars, and while the cotyledons of *Pterocarya* are leaf-like and aerial in germination, those of the Walnut never emerge from the seed.

Chabræus long ago remarked on the wonderful richness of nature as displayed in the Walnut, '*præsertim miranda figuræ luxuria naturam in hoc fructu luisse certum est.*' The Walnut, from its fancied resemblance to a head, the outer woody covering being compared to the skull, and the folds of the cotyledons to the convolutions of the brain, was formerly supposed to be especially efficacious in brain-disease.

In the Walnut (*Juglans regia*) the ovary is one-celled or imperfectly four-celled, one-ovuled; the ovule is erect and orthotropous, with the micropyle superior. The fruit is drupaceous, oblong-globose, crowned with a small point consisting of a three- to five-toothed involucre formed by the union of the bract and bracteoles, by the remains of the four-toothed perianth and the remains of the style; exocarp or rind smooth, and beset with submerged glandular dots bursting irregularly when mature, subfleshy; endocarp hard, bony, or brittle, corrugated, with a spongy lining or inner coat which forms large irregular corrugations internally, and is apparently excavated into four large cavities at the base; the excavations are continued to the top of the main cavity of the ovary, hollowing out the sides of the endocarp so as to furnish a larger amount of space for the seed than is originally provided for it. In Bentham and Hooker's '*Genera Plantarum*' the base of the endocarp is said to be intruded, imperfectly dividing the fruit into two or four cells. The endocarp further consists of two valves or halves, which, however, cannot be separated without force.

The seed is large, strongly and irregularly corrugated, seated on the central and originally basal placenta, which in the mature fruit is about one-third above the base of the cavity of the endocarp, deeply four-lobed at the base and filling the four cavities; the testa is thin, closely applied to the corrugations of the endocarp externally before the seed becomes dried up, and internally to the lobes of the embryo, pale brown.

In the young state the endosperm fills the interior of the seed with a clear jelly-like mass, in the apex of which is the small embryo, with the radicle upwards. Gradually, however, the cotyledons grow and eventually absorb the whole of the endosperm, thus filling the whole of the interior of the

seed, except, of course, the small portion occupied by the plumule and radicle.

We have seen that in the fruit of *Pterocarya* four hollow spaces gradually form themselves in the originally solid fruit, and that into these spaces the seed sends four prolongations, into which again the cotyledons subsequently grow. Now in the Walnut a very similar process takes place, only the hollow spaces are much larger and confluent with the ovarian cavity, so that instead of a solid wall with hollow spaces occupied by the seed, it gives the impression as if the seed were thrown into folds occupied by the wall of the fruit. To occupy these spaces fully, the cotyledons themselves were thrown into folds as we now see them. The fruit of *Pterocarya* is much smaller than that of the Walnut, the ancestors of which doubtless had a smaller fruit. As it increased, the cotyledons became fleshier and fleshier, and found it more and more difficult to make their exit from the seed, until at last they have given up any attempt to do so. Hence the curious folds, with which we are so familiar, are the efforts made by the original leafy cotyledons to occupy the interior of the nut.

*Comparison of the Fruits of Pterocarya and Juglans.*—Thus, then, while essentially similar, the fruits of *Pterocarya* and of the Walnut offer several remarkable differences. They resemble in some respects the relations between the fruits of the Hornbeam and of the Beech. The fruit of *Pterocarya*, like that of the Hornbeam, is winged, which is not the case with the Walnut or the Beech; it is in the two former smaller, and a great deal harder than in the two latter. Again, the cotyledons of *Pterocarya* are aerial, while those of *Juglans* no longer perform the functions of leaves and never quit the seed.

In the Walnut, as in some other trees, it is an advantage that the seeds should be large rather than numerous. In this way they are able to contain a supply of nutriment, which suffices rapidly to carry the young plant above the grasses and other low herbage. These seeds form the food of squirrels and other animals, which accordingly serve to disperse them, and thus perhaps they are enabled to dispense with any other means of transport. Moreover, for such large fruits wings would perhaps be scarcely adequate.

In *Pterocarya*, on the contrary, the fruits are much smaller, and wings therefore more suitable. Possessing in themselves the means of dispersal, they have no need of offering any attraction to animals. In fact every one which is eaten is so much pure loss. Hence, while the shell of the Walnut is sufficiently hard to protect the seed from the severity of the weather, and from the attacks of most insects &c., which would not help in their dispersal, it offers no obstacle to larger animals. That of *Pterocarya*, on the contrary, is very hard and strong, and even the interior portion (the walls and pillars surrounding the four hollows) are of the same character, while in the Walnut they are, comparatively, quite soft.

One reason why the similarity of construction in the two seeds does not at first strike the observer, is that in *Pterocarya* the lobes of the seed evidently enter the pericarp; in *Juglans*, on the contrary, the lobes are so much larger that it rather seems as if the pericarp sent projections into the seed.

That the present condition of the Walnut seedling is not original, we have interesting evidence in the presence of small leaves reduced to minute scales, as in the Oak and many other plants with subterranean cotyledons.

These scales evidently indicate the former presence of actual leaves which are now no longer required. The curious lobings and foldings of the seed in the Walnut also remind us of the time when the cotyledons were variously lobed and folded so as to occupy the whole space in the gradually enlarging seed. At present they seem to fulfil no useful function, except as a storehouse of nourishment for the seedling.

*Seedlings*.—Two very distinct types of seedlings may be noted in the Order, namely, those with subterranean cotyledons and those with aerial ones. The former are represented by *Juglans regia* (fig. 661). The hypocotyl is undeveloped, and the cotyledons remain enclosed in the bony endocarp during germination; they develop petioles sufficiently long to enable the plumule to make its exit from the apex of the nut and grow upwards. The internodes of the stem between the aborted leaves noted in the seed attain a considerable length during germination. Four or five pairs of these scales occur before a perfect leaf is developed. The first perfect form

consists of three leaflets ; the second of five, and the third of four ; but the number may vary according to the vigour of the seedling. The leaflets are serrated, with nerves running into the teeth, while those of the adult tree are entire, with the principal nerves incurved and not reaching the margin.

The cotyledons of *Pterocarya caucasica* are deeply bipartite, and each of the primary divisions again divided for more than half their length. The ultimate segments are oblong-linear. Three out of five nerves terminate at the base of a sinus, and the lateral ones of these fork, giving off a branch into each of the ultimate segments. The first five leaves are simple, lanceolate, acuminate and penninerved, while the ultimate ones are pinnate with numerous pairs of leaflets, and an odd one.

*Juglans regia*, L.

*Pistil* syncarpous, inferior, surmounted by the bract and bracteoles which are adnate to it, forming a small three- to five-toothed involucre. Higher up and inside of this involucre is the small four-lobed perianth.

*Style* very short, deeply bifid, with the two arms broadly linear-oblong, blunt, spreading and recurved, stigmatic all along the upper surface with wavy lamellæ.

*Ovary* of two carpels, one-celled, one-ovuled, with a small cavity just sufficient to accommodate the ovule in the quite young state ; ovule basal, erect, orthotropous, in direct connection with the axial vascular tissue ; micropyle superior.

*Fruit* an ovoid drupe surmounted by the beak-like remains of the style, densely pubescent in the young state at least, one-celled, one-seeded ; exocarp fleshy, at length bursting irregularly, and falling off ; endocarp woody, forming the shell of the nut, which is corrugated externally and deeply excavated or chambered internally making the fruit appear two- to four-celled, indehiscent, but separable into halves.

*Seed* deeply two- to four-lobed at the base, tapering upwards into a somewhat wedge-shaped but rounded or blunt point ; testa membranous.

*Embryo* large, fleshy, colourless, conforming to the seed, and that again to the inner lining of the endocarp ; cotyledons four-lobed and slightly auricled at the base, closely adpressed, wrinkled and appearing like one continuous piece, constituting the greater part of the embryo, subterranean in germination ; radicle superior, close under



the base of the style, very short, blunt, occupying the pointed apex of the seed, projecting from between the notches at the base of the cotyledons, somewhat compressed right and left, i.e. in the same plane as the cotyledons; plumule conical with a row of five minute buds or leaves along two sides and opposite to the cotyledons, with two perfect leaves each having about three leaflets alternating with them.

#### ORIGIN OF INTERNAL CAVITIES OF THE FRUIT.

A vertical section of a young fruit made on the 4th of June shows the exocarp already differentiated from the tissue within it and containing chlorophyll in its cells. The endocarp is colourless but contains plenty of protoplasm. Surrounding the central ovule, and projecting on each side from its base, is a layer of tissue of a watery appearance, and having little or no cell-contents, but perfectly unbroken.

A transverse section of another fruit, made about the same date, shows a similar but thin layer of watery tissue surrounding the ovule; and on one side of the latter, but extending more than half way to the periphery of the endocarp, are two irregular-shaped similar areas.

A vertical section of the fruit made on the 21st of June showed the watery colourless tissue greatly increased in bulk, and extending with two long branches nearly to the base of the endocarp, where they widen. The broader parts of this tissue are beginning to break up.

A corresponding transverse section shows four masses of watery or cortical parenchyma, with a cavity in the centre of each, formed by the breaking up of the cells which were originally continuous with the rest of the endocarp.

A longitudinal section of the fruit made on the 8th of July showed that the cortical and watery parenchyma had previous to this greatly increased in bulk and become dissolved. The testa has grown contemporaneously with the breaking up of the tissue of the ovary, and by continuously adjusting itself by growth to the interior of the cavity, now almost completely fills it including the various irregular hollows or excavations. The tissue of the nucellus has become deliquescent and watery, while as yet the embryo is extremely minute and difficult to detect.

A corresponding transverse section shows the four main cavities now formed in the fruit, together with several minor ones. The testa for some reason or other has not been able to develop to the bottom of some of the recesses, possibly on account of their being

narrow. Some of the cavities are still in process of excavation, and the cortical matter is white while the rest of the endocarp is darker and slightly tinted with green. The interior of the seed is lined with jelly-like protoplasmic matter while the central hollow part is occupied with a liquid.

**Seedling (fig. 661).**

*Primary root* very stout, woody, tapering downwards, subflexuose, emerging from the apex of the nut, and furnished with lateral rootlets.

*Hypocotyl* very short, stout, woody, scarcely distinguishable from the root.

*Cotyledons* large, fleshy, obovate, bilobed, crumpled, filling the whole cavity of the seed and remaining there after the germination of the plant, attached to the young plant by their short fleshy petioles.

*Stem* woody, erect, stout, compressed, glabrous, whitish beneath the soil, deep green above and covered with little grey or brown lenticels; 1st internode 2.5 cm. long; 2nd 2.3 cm.; 3rd 1.8 cm.; 4th 2.5 cm.; 5th and 6th each 1.6 cm.; 7th 7 mm. These lengths vary according to the vigour of the seedling.



FIG. 661.  
*Juglans regia*.  
One-tenth nat. size.

*Leaves* compound, imparipinnate (first eight in specimen reduced to scales and opposite or subopposite in four pairs), cauline, alternate, exstipulate, petiolate, deciduous, glabrous except tufts of hairs in the forks of the veins on the under side of the leaves of the adult tree, deep green above, paler beneath, shining; leaflets penninerved, with alternate, ascending nerves incurved at their tips, alternate or subopposite, and frequently not evenly paired, the odd one when next the terminal leaflet apparently cut away from the base of the latter, making it unequal at the base, more or less regularly serrate in the young plant and quite entire in the adult tree; petioles subterete, tapering upward from a stout base, flattened on the upper side and slightly channelled, but in the adult tree terete and not flattened or channelled except at the dilated clasping base.

Nos. 1-8. Reduced to small alternate or nearly opposite scales.

No. 9. Trifoliolate; terminal leaflet large, obovate, or elliptic, cuspidate; lateral leaflets small, oblong, alternate.

No. 10. Five-foliolate; terminal leaflet oblong-obovate; middle pair ovate, acuminate, oblique on the anterior basal side, unequal,

subopposite; basal pair small, unequal, ovate, oblique on the anterior basal side.

No. 11. Four-foliolate; leaflets alternate, all unequal; terminal one ovate-oval, subacuminate, very unequal at the base; the other three leaflets ovate, subacuminate, oblique on the anterior basal side, much smaller than the terminal one.

The serrate character of the primary leaves of the seedling is very noticeable, as well as the fact that all or nearly all of the primary or stronger lateral veins run to the tips of the teeth.

Ultimate leaves imparipinnately three- to nine-foliolate; leaflets alternate or sometimes subopposite, unequal in size, entire, oblique on the anterior basal side; terminal leaflet much the largest, oblong-elliptic, cuspidate; lateral leaflets oblong or ovate-oblong, obtuse or cuspidate or subacuminate, gradually smaller towards the base of the leaf.

M. Flèche has pointed out <sup>1</sup> that the young leaves differ in being more acuminate, with nerves running to points, and altogether more like those of some species of *Carya*.

### *Juglans nigra*, L.

*Ovary* one-celled or partly four-celled at the base and apex, one-ovuled; ovule as in *J. regia*.

*Fruit* globose, one-celled, or nearly four-celled by the projection of ribs of the endocarp into the interior from the base and apex, green, covered externally with little warts and sessile glands, tipped with the persistent remains of the style and the superior perianth; epicarp fleshy; endocarp bony, thick and projecting very much into the interior of the fruit, with numerous shallow cavities on its inner face; placenta basal, one-seeded.

*Seed* solitary, erect, deeply four-lobed; lobes reniform or transversely oval, constricted at their union with the central body of the seed, projecting into each of the four large cavities of the ovary, and raised into numerous gibbosities or swellings to conform to the interior; testa marked with numerous long, forking veins proceeding from the basal chalaza and radiating all over the lobes to the radicle, white or creamy yellow, double; tegmen paler, thinner.

*Endosperm* absent in the mature seed, but in the young state filling all the interior of the ovule with a clear, jelly-like mass on the top of which the cotyledons lie astride with the radicle close to the apex, and therefore distant from the hilum.

*Embryo* straight, colourless, fleshy, ultimately occupying all the

<sup>1</sup> *Bull. Soc. des Sciences, Nancy, 1886.*

interior of the seed ; cotyledons bilobed and the lobes again bifid with the secondary segments entire or emarginate (in the immature state), slightly auricled at the base ; radicle short, stout, triangular, pointed.

*Pterocarya caucasica*, C. A. Mey.

*Fruit* sessile, inferior, tipped with four tooth-like perianth-segments, seated in the axil of a small bract, which for more than half its length is adnate to the anterior part of the fruit, with two oblique wings consisting of two enlarged bracteoles adnate to and enclosing more than half of the fruit.

The wings are obliquely attached to the fruit owing to its ascending direction, and themselves ascend vertically towards the apex of the spike, diverging laterally until they meet those of the contiguous row of fruits on each side.

*Ovary* of two carpels, one-celled, but partly two- to four-celled, especially in the lower part ; ovule orthotropous, on an elevated, but really basal placenta formed by the infolding and union of the margins of the carpels.

A transverse section of the ovary near the base shows four cavities which in the early stage of the fruit are not empty but filled with light, white, spongy or cortical material, becoming dry, brown and easily crushed into little space when the testa of the seed develops.

The young fruit when examined about the last week of May shows the pistil, subtended at the base anteriorly by a small bract, and at the sides by two bracteoles adnate to its base. Perianth leaves four, inserted on the neck of the pistil a short way beneath the two large spreading coarsely papillose stigmas. The cavity of the ovary is small and nearly filled by the minute ovule. The tissues surrounding the ovule are all coloured alike, and no cavities or cortical tissue are seen.

By the 11th of June all parts of the young fruit have increased very much in thickness, but not much in length. The ovule is much larger, with the distinctly discernible coat slightly overtopping it. The ovary is much wider, and at its base (in longitudinal section) are two whitish masses of tissue, definite in outline and almost colourless, as if the protoplasm had been removed, leaving nothing but water in the cells.

By the 25th of June the young fruit has increased greatly in both length and breadth. The bracteoles are larger, and the space between the base of the fruit and the ovule has elongated. The chief difference, however, is in the coat of the ovule, which is now twice

as long as the nucellus, and wide open at the apex. The colourless tissue on each side at the base of the ovule has not much altered, but vascular tissue begins to make its appearance.

About the first week in July there seems no difference in the size of the ovule, but the fruit as a whole continues to grow rapidly. The bracteoles originally near the base of the fruit have been carried a long way up. The neck has also been shortened by the thickening of its basal portion. The vascular tissue has increased. Other and more important changes have also taken place. On each side of the ovule two oblong curved patches of tissue are seen lying about half way between it and the exterior of the fruit; these are losing colour in the same manner as the above-mentioned masses at the base of the ovule.

In transverse section colourless tissue, evidently becoming cortical, is seen to surround the ovule. On each side of the ovule towards the circumference of the fruit four irregularly circular pieces of colourless or cortical tissue are seen. The ovule is oval in outline in the transverse section. The framework of the fruit, which ultimately becomes sclerenchymatous, already commences to show itself.

The ovule by the 23rd of July has increased but little in size, but differs somewhat in shape from that of earlier stages. The principal alterations are in the cortical tissues. In longitudinal section a large oval or elliptic mass of cortex is seen on each side of the fruit, mostly above the level of the ovule and close to the rind. Two large masses also extend from the ovule downwards towards the base of the fruit. Bounding all these masses are bands of tissue that ultimately become sclerenchymatous. The cortex is as yet solid. The cavity of the ovary is small. The bracteoles forming the wings have grown nearly to the top of the fruit on the posterior side, while they descend towards the base on the anterior side.

In the transverse section at this stage four masses of cortex are seen, two on the right and two on the left.

A longitudinal section of the fruit about the 6th of August shows two longitudinal masses of cortex and a transverse piece, lying as it were across the top of the two. All are separated by a framework of vascular and sclerenchymatous tissue, or tissue rapidly becoming sclerenchymatous.

In the transverse section in a much more advanced state taken at the very base of the ovary, a central line of small solid masses of cortex is seen. Right and left the usual four masses of cortex have now become almost completely absorbed, leaving strands and broken pieces running across the cavity.

In a corresponding vertical section through the axis of the fruit, the ovary, together with what used to be two longitudinal masses of cortex, have become one continuous cavity. The cortex is not yet wholly absorbed, but lines the sides of the cavity. Two masses of cortex show themselves mostly above the ovary, one on each side; but they are still solid. The ovule is flask-shaped, but still very small. The vascular and sclerenchymatous tissue is getting very firm.

On the 18th of August the ovule has increased so as to fill the whole cavity of the ovary. A longitudinal section through the axis shows two masses of cortex on the upper side. In a corresponding transverse section the ovule again nearly fills the cavity. Four solid masses of cortex are seen, two right and two left of the axis.

In a transverse section taken lower down than the last and corresponding to it in age, the connection of the ovary cavity with the four cavities formed by the absorption of cortical tissue is seen. Across the opening of some of the cavities strands of cortical tissue still remain.

In a transverse section made on the 1st of September, the seed filled the cavity of the ovary and lay nearly at right angles to its usual position with regard to the axis. The two cotyledons of the young embryo were seen lying in the middle. Some masses of solid cortex may still be seen at this date. A corresponding longitudinal section shows the embryo, the cotyledons of which are already four-lobed. The seed has descended into the basal cavities. The hard sclerenchyma has now greatly increased in thickness, making a framework for the fruit and rendering it hard and brittle.

A longitudinal section of a barren fruit, made on the 12th of September, showed the small flask-shaped ovule, and the nearly empty cavities at the base of the ovary cavity. Some solid masses of cortex appeared both above and below the ovary.

By the 19th of September the embryo has greatly increased in size, filling the seed, which nearly occupies the whole of the space in the ovary cavity, and also the cavities extending below the latter. Lobes of the cotyledons are seen to descend into these basal cavities. These cavities are not yet completely filled with the lobes of the seed.

A transverse section through the fruit and seed at this date showed the embryo more advanced than in the last case, and the cotyledons very much plaited or folded. Above and at the sides of the ovary the cortex never becomes absorbed so as to form cavities like those four pieces beneath the ovary. Four large pieces may be seen, two on each side of the seed, and still quite solid.

In a transverse section of the fruit made below the base of the ovary, the four cavities are seen to be filled with the twisted or folded lobes of the cotyledons.

A longitudinal, but slightly oblique, section through the fruit was made on the 12th of October. Owing to the cotyledons being much folded and twisted, a clear idea of their arrangement can scarcely be obtained in longitudinal section. The radicle is seen at the apex of the seed which is orthotropous. At the base of the cavities formed by the absorption of cortex, the tips of the cotyledonary lobes in some instances appear to be folded transversely. A mass of cortex occupies the apex of the fruit. By this date it had not been fully matured and had been damaged by frost; that is, the exterior parts such as the rind and wings.

In a transverse section of the same date the cotyledonary lobes are seen to be variously folded in the same fruit.

Masses of cortex occur in various parts of the fruit, embedded in the more solid and sclerenchymatous endocarp. They are doubtless intended to lighten the fruit, and aid in its dissemination by means of the wind. The wings formed by the adnate and accrescent bracteoles, and the very thin rind or exocarp of *Pterocarya*, all point to the natural means of dispersing the fruit in this genus.

### Seedling (fig. 662).

*Hypocotyl* erect, terete, brownish and glabrous in the lower part, greenish upwards and thinly pubescent, about 8 cm. above the soil.

*Cotyledons* bipartite, with the primary divisions narrowing to a cuneate base, and again deeply bipartite, making in all four linear-oblong, obtuse, entire, diverging and recurved segments, five-nerved from the base of the lamina, glabrous, dull opaque-green above, paler beneath; midrib slender, short, ending at the base of the middle fissure of the lamina; middle nerve on each side of the midrib strong, running along the middle of the primary divisions of the cotyledons and ending with a slender point at the base of their fissure, at the same time giving off a strong lateral nerve on each side a little below the apex, which runs along the middle of the ultimate



FIG. 662.  
*Pterocarya caucasica*.  
Nat. size.

segments; slender nerves run from the base of the lamina near the outer edge more than half way towards the apex; petiole short, deeply grooved above, convex on the back, glabrous, about 2.25 mm. long; lamina 1.5–1.8 cm. long, 2.3–2.5 cm. wide between the tips of the outer segments.

*Stem* erect, terete, glabrous or thinly pubescent, green, ultimately woody; 1st internode 2.25 mm. long.

*Leaves* compound, cauline, alternate, exstipulate, petiolate, imparipinnate, penninerved; leaflets serrate, numerous.

No. 1. Oblong or lanceolate, obtuse or acute, rather distantly serrate, simple, sessile or subsessile, glabrous or nearly so, alternately penninerved, with a nerve running into each serrature.

Nos. 2–5. With more elongated petioles, lanceolate, acuminate, larger, but otherwise similar to the first.

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## MYRICACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 400.

*Fruit and Seed.*—The ovary is one-celled with a solitary, basal, erect, orthotropous ovule. The fruit is small, globose or ovoid, with a fleshy or succulent exocarp and a bony endocarp. The seed is erect and exalbuminous with a membranous testa. The embryo is straight, with fleshy plano-convex cotyledons and a short superior radicle, the whole conforming in shape to that of the seed.

*Seedling.*—*Myrica californica* (fig. 663) may serve as a type of the Order. The cotyledons are spatulate-obovate, tapered to the base, with several slender, ascending nerves on each side of the midrib, best seen when fading. The first leaf is small and cuneate, followed by three which are cuneate or rhomboid, trifid and serrate. The fifth and sixth are narrowly ovate; and the seventh to the tenth inclusive are oblong and acute. The primary leaves as well as the cotyledons bear a strong resemblance to those of *Cratægus Oxyacantha*, but they are covered with oily or resinous glands. The roots are plentifully supplied with small tuberous processes.



***Myrica californica*, Cham. et Schl. (fig. 668).**

*Primary root* long, tapering, flexuose, with numerous lateral rootlets, and furnished here and there with small fleshy tubercles or nodosities.

*Hypocotyl* terete, glabrous, red, soon becoming woody.

*Cotyledons* spatulate-obovate, suddenly narrowed to a subacute apex, gradually tapered to the base, sessile, glabrous, with a distinct

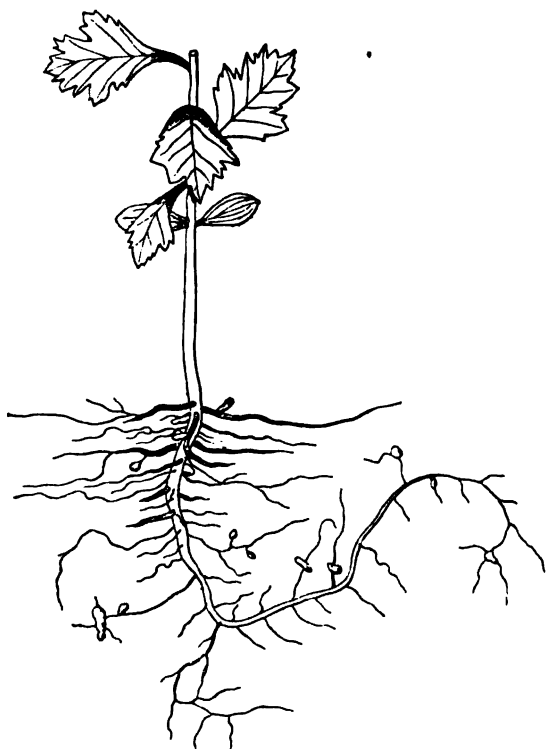


FIG. 668.—*Myrica californica*. Nat. size.

midrib and several slender nerves ascending from near the base (probably best seen when the cotyledons are fading), reticulated towards the apex, 9 mm. long, 4 mm. wide.

*Stem* erect, terete, hairy, glandular, red, soon becoming woody; 1st internode 6.5 mm. long; 2nd 4 mm.; 3rd 7 mm.

*Leaves* simple, cauline, alternate, exstipulate, petiolate, alternately penninerved, thinly hairy above, but more especially on the

upper side of the petiole, and densely covered with small oily glands on the upper surface, most distinctly visible when young; petiole semiterete, flat above, somewhat dilated at its insertion on the stem.

No. 1. Narrowly cuneate, serrate above the middle.

Nos. 2-4. Cuneate, or subrhomboid, shallowly trifold and serrate, similar to the leaves of the common Hawthorn (*Cratægus Oxyacantha*).

Nos. 5 and 6. Narrowly ovate, cuneate at the base, irregularly and slightly doubly serrate.

Nos. 7-10. Oblong, acute, cuneate at the base, sharply and somewhat doubly serrate.

The seedling bears considerable resemblance to a young *Cratægus* or *Prunus*, both in the cotyledons and leaves. It also resembles a young *Betula*, but the cotyledons are much larger, and the leaves from the seventh onwards become oblong. The glands on the stems and leaves, the penninerved venation and the oblong leaves from the seventh onwards are however characteristic of *Myrica*. The small tubercles on the roots recall those of *Alnus cordifolia* amongst the *Cupuliferæ*.

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## CASUARINÆ.

Benth. et Hook. *Gen. Pl.* iii. 401.

*Fruit and Seed.*—The ovary is very small with twin, collateral, ascending, semi-anatropous ovules, having a superior micropyle. The fruits are ovoid or cylindrical, covered with accrescent bracts and bracteoles, and arranged in a dense cone-like head. The nut is laterally compressed, produced into a wing running along the sides of the style and indehiscent. The seed is solitary by abortion and exalbuminous. The embryo is straight with flattened cotyledons and a superior radicle.

*Seedling.*—The cotyledons of *Casuarina Cunninghamiana* (fig. 664) are oval, obtuse, and sessile. The stem is quadrangular in the seedling stage. The first two leaves are opposite, followed by at least nineteen whorls of four leaves each, decussating and forming the angles of the stem. They are adnate to the stem for the greater part of their length and

free at the tips only. In this respect they bear a strong resemblance to the Equisetaceæ and some of the Coniferæ.

*Casuarina Cunninghamiana*, Miq. (fig. 664).

*Primary root* slender, wiry, flexuose, with similar lateral fibres.

*Hypocotyl* erect, terete, glabrous, wiry, deep shining brown, very slender, 6·5 mm.—2·1 cm. long.

*Cotyledons* oval, obtuse, entire, sessile,



FIG. 664.—*Casuarina Cunninghamiana*,  $\times 2$ .

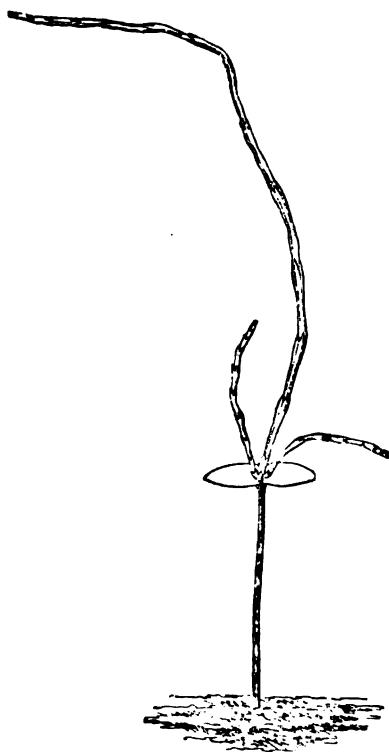


FIG. 665.—*Casuarina stricta*. Nat. size.

glabrous, with a midrib slightly discernible on the under side by transmitted light, deep green above, paler beneath, 3–4·25 mm. long, 1·5–2·5 mm. wide.

*Stem* erect, quadrangular in the seedling stage, glabrous, and entirely covered by the decurrent and adnate bases of the leaves, deep green, ultimately woody; 1st internode undeveloped and all the rest very short.

*Leaves* simple, entire, cauline, verticillate, exstipulate, sessile, wholly adnate to the stem except the small tooth-like tips, glabrous, deep green, with pale margins to the tooth-like tips, without any discernible venation, the whorls alternating one with another, and by so doing forming the short alternating angles of the stem which correspond with the lengths of the decurrent leaves and the internodes.

Nos. 1 and 2. Very short, opposite, almost arising from the same level as the cotyledons and followed by nineteen whorls consisting each of four leaves, forming the angles of the stem, and decussating or alternating one with another, with very minute free tips.

*Casuarina stricta*, Ait. (fig. 665).

*Hypocotyl* erect, terete, rising about 3 cm. above the soil.

*Cotyledons* ovate-oblong, sessile, connate, and appearing perfoliate, narrowed upwards to an obtuse point, horizontal, 7.5 mm. long, and 3 mm. wide.

*Stem* erect, ridged and furrowed, owing to the base of the scale-like leaves being decurrent upon it; 1st internode very short; 2nd and 3rd 8 mm. long; 4th to 6th 9 mm.; succeeding ones shorter. The stem and branches are articulated much like those of an *Equisetum*, and the branches or the smaller ones ultimately become disarticulated and fall like deciduous leaves.

*Leaves* simple, cauline, whorled, with the whorls decussating, reduced to small scales, sometimes more or less connate at the base and sheathing the stem, the midribs decurrent upon the latter forming slender ridges, those above alternating with those below each whorl. The number of leaves in a whorl varies from four to many, according to the thickness of the young shoots bearing them.

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## CUPULIFERÆ.

Benth. et Hook. *Gen. Pl.* iii. 402.

*Fruit and Seed*.—The ovary is inferior, and during the period of flowering often appears quite solid, but after fertilisation it becomes more or less perfectly two- to three-celled,

rarely four- to six-celled. The ovules are solitary in each cell or twin and collateral, inserted at or near the apex of axile placentas, pendulous and anatropous or nearly so, with a superior micropyle. The fruit is a one-celled nut and variously surrounded or included in a cupule consisting of bracts or bracteoles more or less cohering or grown together. The shell of the fruit is crustaceous or woody and indehiscent. The seed is most often solitary by abortion and exalbuminous with a membranous testa. The cotyledons are fleshy or much folded and foliaceous, while the radicle is short and superior.

About five more or less distinct types of seeds have come under my observation. The fruit or nut of *Carpinus Betulus* (the Hornbeam) is ovate, and the solitary pendulous seed is obovate. The embryo is straight and fleshy, with obovate, entire, or emarginate cotyledons. The emargination is due to the fruit being occasionally more markedly umbilicate than usual at the base with the wall projecting into the cavity at that point. The short radicle projects slightly beyond the cotyledons.

A second type occurs in *Corylus Avellana* (the Hazelnut) (fig. 668) which in the wild state has a more or less globose fruit surrounded by a leafy cupule. The cultivated Cobs and Filberts, varieties of this species, have much larger and more or less oblong fruits. The seed conforms to the interior, is solitary and suspended from the apex of a filamentous, originally axial placenta. The young ovary is two-celled, but the septa become ruptured and lost at an early stage, leaving the placenta free. The latter gets pushed against the sides of the pericarp, and is curved, like the seed, in conformity with its outline, and bears the remains of three aborted ovules at its apex, besides a perfect seed. In some botanical text-books the filamentous placenta is spoken of as the raphe. Strong slightly forked nerves radiate from the chalaza all over the testa towards the micropyle. The raphe and chalaza are ventral and next the cord-like placenta. The embryo is fleshy with plano-convex or hemispherical cotyledons enclosing the small plumule and the short superior radicle. The seed of *Corylus Colurna* is more ovoid and somewhat compressed, with the embryo conforming to the interior. The

cotyledons are plano-convex, and obovate, but in all other respects this species conforms to the type.

The fruit or acorn of *Quercus pedunculata* (fig. 669) is oblong, one-celled and one-seeded. The cotyledons are fleshy, oblong, obtuse or slightly emarginate owing to a thickening at the chalaza, and auricled at the base; but the auricles fit closely to one another, hiding all but the extreme tip of the short radicle. The fruit is surrounded at the base by a scaly, cup-shaped involucre. In the earliest stages it is a three-celled ovary with two ovules in each cell suspended from near the middle of the axial placentas. Soon after fertilisation one ovule develops at the expense of all the others, pushing them aside as well as the placentas, so that at this stage the ovary in either transverse or longitudinal section appears lopsided. The septa become ruptured or destroyed and the placenta-bearing axis gets severed from the apex of the ovary and ceases to lengthen. The ovule in the early stage is pendulous, and anatropous with the hilum a little below the top. As the ovary increases in length and the axial column gets torn from the top, the young seed increases in length much faster above than below its attachment, till in the full-grown state it is practically orthotropous. The chalaza is basal and gives off numerous, strong, branching veins radiating all over the testa up to the micropyle. It is really very close to the hilum owing to the extreme shortness of the raphe (see diagram, fig. 669). The seed is sessile and the axial column really very short and firmly squeezed against the base of the ovary by the seed which completely fills the cavity.

A fourth type is represented by *Castanea vulgaris* (the Chestnut) the fruits of which are generally grouped three together within a four-leaved bristly involucre. The ovary consists of six to nine carpels, uniting to form as many cells with a pair of pendulous anatropous ovules in each cell. It soon becomes one-celled by the rupture of the placentas, and one, rarely two, seeds develop at the expense of the rest. The ovary is densely lined internally with silky hairs. The seed is ovoid or triangular-ovoid according to the pressure brought to bear upon it by others. The cotyledons become concave

towards one another at an early stage, and ultimately fleshy, occupying the whole of the seed, wrinkled both internally and externally, undulate and interlocking with one another at the margin.

*Fagus sylvatica* (the Beech) constitutes a fifth type. The cupule consists of numerous bracteoles amalgamated in four large pieces which completely enclose the two to four, generally two fruits, and ultimately spread open to allow of the dispersion of the latter, which are triquetrous with three wings extending from the apex to below the middle. The seed is bluntly trigonous and does not completely fill the angles of the fruit. The fruit is three-celled in the ovarian stage, with two anatropous ovules suspended from near the apex of each cell. In nearly every case one ovule develops at the expense of the rest. The ovary soon becomes one-celled by the rupturing of the septa; but the axial column remains attached to the apex of the cavity and carries the anatropous seed suspended from near the apex. The embryo at an early stage becomes doubled upon itself longitudinally and covers two of the sides of the triangular cavity. Then growth continuing at the edges of the cotyledons the primary folds are pushed into the centre of the cavity. The edges of the cotyledons become reversed towards the angle of the ovary occupied by their middle portion; and when they have grown in this direction till they again meet with resistance, they double back again so that in the full-grown seed they consist of four folds so arranged as to fill the trigonous seed and that again the triquetrous fruit. They can therefore become aerial and green during germination, and differ in these respects from any of those mentioned above.

The greater number of the fruits of this Order are adapted to be transported by animals, to which they serve as food. Those of the Hornbeam, however, are winged.

*Seedlings*.—Four more or less distinct types coming under my observation have aerial cotyledons, while in a fifth case they are subterranean during germination. The simplest type is that of *Betula alba* (fig. 672) which has small, oblong-ovate, shortly stalked cotyledons, showing a faint midrib. The first two leaves are ovate, followed by three more or less triangular ones. The sixth is cordate. All are unequally serrate and

penninerved with the basal pair of nerves the strongest. The leaves of the adult are doubly serrate or even somewhat lobed.

The cotyledons of *Alnus cordifolia* (fig. 666) are oblong-oval, entire, and obscurely trinerved at the base. The first two leaves are broadly ovate; and the three following ones are more or less cordate and broad; all are serrate. The cotyledons of *Alnus incana laciniata* differ in being broadly oval, emarginate, and faintly showing a midrib. The first leaf is broadly cuneate and coarsely serrate.

*Carpinus Betulus* (fig. 667) is very distinct from any of the above, and has roundly obovate, shortly petiolate cotyledons distinctly auricled at the base of the lamina. The first leaf is broadly triangular, lobulate and serrate; the second is ovate-subcordate; and the third ovate. All have a penninerved venation, but this is particularly well marked in the adult leaves, which are also plicate, and finely doubly serrate.

One of the most striking types in the Order is that of *Fagus sylvatica* (fig. 671) which has large, foliaceous, transversely oval and sessile cotyledons, auricled at the base, and longitudinally plicate, with many radiating forking veins, branching from two primary ones and spreading over the lamina in a fan-shaped manner. The lamina further is entire or obscurely crenate along the apical margin, and is 1.7-3 cm. long and 3-4.7 cm. wide. This peculiar shape and great size is due to their being membranous and much folded in the seed so as to occupy the whole interior of the triquetrous fruit to which the trigonous seed conforms. The first two leaves are opposite, ovate, obscurely dentate, penninerved, with the veins slightly incurved at their tips or running into the marginal teeth. The third leaf is alternate, broadly ovate, obscurely crenate, much smaller than the first two, and generally terminates the first season's growth.

The cotyledons of *Quercus Ilex* (fig. 670) are oblong, plano-convex, fleshy and subterranean. They are auricled at the base and petiolate, and although the pericarp splits longitudinally when they swell during germination, they never quit the acorn. The first five leaves are linear-subulate, minute, scarious, brownish and caducous. The sixth is some-



what larger, cuneate and trifid at the apex; the seventh and eighth are foliaceous but small. The ninth is much larger, lanceolate-oblong, and distantly serrate. The tenth to the thirteenth inclusive are elliptic-oblong, irregularly penninerved and acutely serrate. The above characters of the primary leaves vary according to the vigour of the seedling and the conditions under which germination takes place. The primary internodes have not the power of elongating, so that when an acorn happens to be deeply buried with dead leaves in a wood or plantation the primary leaves are arrested in growth and scale-like, while those leaves or most of those (probably never all) which reach the light become green and foliaceous. The leaves of the adult tree are mostly quite entire except in the variety *Q. I. serratifolia*.

The cotyledons of *Q. pedunculata* are also subterranean. Several of the primary leaves are reduced to scales as in the last case and probably for the same reason. The first green and foliaceous leaf is obovate-oblong and shallowly lobed at the top. Succeeding ones are obovate or obovate-oblong, and irregularly lobed with alternate nerves running into the lobes. The cotyledons of *Corylus* are also subterranean.

***Alnus cordifolia*, Ten. (fig. 666).**

*Primary root* tapering, flexuose, with a few small lateral rootlets knotted with sessile tubercles.

*Hypocotyl* woody, erect, terete, finely pubescent, brown, 1.75 cm. long.

*Cotyledons* broadly oblong or oblong-oval, obtuse, petiolate, glabrous, rather fleshy, obscurely trinerved at the base, pale green; lamina 7.5 mm. long, 5 mm. wide; petiole grooved above, rounded and slightly pubescent on the back, 2 mm. long.

*Stem* woody, erect, terete, pubescent, brown; 1st internode 4.25 mm. long; 2nd 3 mm.; 3rd 3.25 mm.

*Leaves* simple, cauline, alternate, stipulate, petiolate, thinly

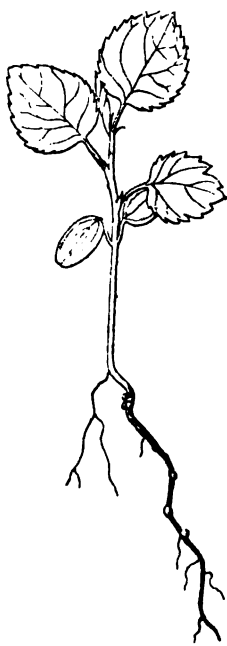


FIG. 666.  
*Alnus cordifolia*.  
Nat. size.

scaly above, floccose along the midrib and base of principal nerves with dirty white hairs, otherwise glabrous, deep green and shining above, paler beneath, alternately penninerved, finely reticulate; petioles terete, glabrous, obsoletely channelled on the upper side, scaly when young, tapering upwards from a stoutish base; stipules lanceolate, acute, scaly on the back, soon becoming revolute and caducous; leaf-buds viscid.

Nos. 1 and 2. Small, broadly ovate, acute, or cuspidate, irregularly and acutely serrate, slightly unequal at the base.

No. 3. Broadly subcordate, acute, irregularly and acutely serrate.

Nos. 4 and 5. Ovate-subcordate.

Ultimate leaves cordate, obtuse, cuspidate, minutely and mucronately serrate-dentate; larger nerves subincurved.

### ***Carpinus Betulus, L.***

*Ovary* of two carpels, one-celled or imperfectly two-celled in a very young state, with two ovules in one or both of the cells; ovules pendulous, anatropous; micropyle superior, close to the hilum.

*Fruit* a nut, ovate, compressed, umbilicate at the base, tipped with the persistent, superior, perianth-segments (which are unequal in size and irregular in number), strongly eight- to nine-ribbed, glabrous, green, ultimately yellowish; endocarp bony; pericarp thin, brown, membranous.

*Seed* obovate, compressed, pendulous from the top of the cavity, entirely occupying the interior of the nut, and conforming to its shape; radicle superior, close to the hilum; raphe ventral on one edge of the seed, sometimes removable; chalaza ventral, a little above the base on one angle, sending off a nerve to the base which forks there, one branch passing along each side of the apex of the cotyledons, besides four on each face of the seed which occasionally fork. These nerves however are not always constant in number, and may be different on the two sides of the same seed.

*Embryo* straight, large, and occupying the whole of the interior of the seed to which it conforms; cotyledons obovate or oval, applied face to face, colourless, shining, fleshy, slightly convex on the back, entire at both ends, or sometimes emarginate at the apex; radicle superior, slightly protruded beyond the cotyledons.

### **Seedling (fig. 667).**

*Primary root* short, tapering, dark-coloured, giving off small wiry rootlets, flexuose.

*Hypocotyl* erect, terete, soon becoming woody, flexuose, shortly pubescent, brownish, 3-4.5 mm. long.

*Cotyledons* rotund-obovate, obtuse, shortly petiolate, auricled at the base, concave on the upper face, rather fleshy, green and rising above the soil, glabrous except the petiole, which is short, slightly grooved on the upper side and pubescent, 1.5 mm. long.

*Stem* soon becoming woody, erect, terete, zigzag from leaf to leaf, pubescent; 1st internode .75 mm. long; 2nd 1.5 mm.; 3rd 3.5 mm.; 4th 2.25 mm.

*Leaves* simple, cauline, alternate, stipulate, petiolate, glabrous except on the nerves beneath and the petioles, penninerved with ascending parallel nerves running into the serratures, plicate, especially when young, doubly and cuspidately acuminate, serrate; petioles slender, channelled above, short, pubescent; stipules free, subulate, acute, hairy, brownish-green.

No. 1. Triangularly ovate, lobulate and doubly serrate, with acute serratures.

No. 2. Ovate-subcordate, acute, doubly serrate.

No. 3. Ovate, acute, narrowed slightly at the base, but rounded, doubly serrate.

Ultimate leaves ovate, acuminate, doubly serrate, slightly unequal at the base, plicate, with ascending parallel nerves, glabrous above, sparsely hairy on the nerves beneath with a woolly tuft in the axils of the lateral veins where they join with the midrib, petiolate; petioles terete, hairy, tapering upwards from a stout base, 8–12 mm. long.

*Corylus Avellana*, DC. f. (fig. 668).

*Ovary* of two carpels, two-celled, each cell two-ovuled; ovules pendulous, anatropous; micropyle superior.

*Fruit* a glans or nut surrounded at the base by an involucre which is double (the outer series or bracts being short and little cut, the inner or bracteoles large, accrescent and deeply lacinated), oblong-ovoid, ovoid or globose, glabrous except at the top which is densely and finely



FIG. 667.  
*Carpinus Betulus*. Nat. size.

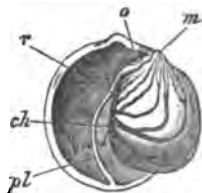


FIG. 668.—*Corylus Avellana*.  
Vertical section of nut, nat. size,  
with seed pulled out: o, aborted  
ovule; m, micropyle; pl, placen-  
tal axis; r, raphe; ch, chalaza.

pubescent, and marked with two scars showing the remains or trace of the perianth, and indicating the bicarpellary nature of the fruit, indehiscent, one-celled, one-seeded, with remains of three aborted ovules, one of which in some rare instances seems to have been fertilised and grown to some size; pericarp woody, lined internally with brown spongy and scaly matter.

*Seed* globose or otherwise conforming to the shape of the pericarp, suddenly narrowed to a short point at the apex, pale yellowish-white, strongly marked with diverging simple or slightly forking veins radiating from the chalaza to the micropyle; raphe about 8.5 mm. long, ventral and next to the cord-like placenta arising from the base of the fruit and passing along the side of the seed (cf. *Quercus*); hilum lateral a little below the apex; micropyle and radicle superior; testa thin, membranous.

*Embryo* straight, occupying the whole interior of the seed, fleshy, yellowish-white; cotyledons plano-convex, thick, oily, each occupying half of the seed, semi-orbicular, cuspidate at the apex, or oblong-cuspidate; radicle small, superior; plumule small.

*Germination*.—The thick cotyledons remain in the fruit, and are not carried above the soil. The plumule forces itself out of the nut and develops hypocotyl and rootlet. The cotyledons gradually become aborted; at their outer side are seen two yellow swellings (rudimentary stipules) which also remain in the earth.

***Quercus pedunculata*, Ehrh. (fig. 669).**

#### EARLY DEVELOPMENT OF FRUIT AND SEED.

When the acorn and cupule together equal the size of a pea, all the ovules are of equal size and decidedly pendulous, oblong, obtuse at the lower and apical end, narrowed above the attachment with the micropyle prolonged into a small, obtuse, hooked point; the raphe is ventral; the chalaza apical and inferior; the hilum forming a longish attachment on the ventral aspect with no free funicle.

After fertilisation one ovule develops rapidly, becoming more or less broadly ovoid, attached to the axis along one side, with the subconical, obtuse, micropylar process still free and somewhat conspicuous. The cell containing this ovule is the only one that develops, containing the young seed and one aborted ovule. The other two cells of the ovary remain small and gradually become pushed on one side with their aborted ovules.

When the acorn has attained a diameter of 1.1 cm., and a length of 1 cm. including the withered styles, the young seed is

still distinctly pendulous, but is now oblong-obovoid, apiculate, and the placenta remaining short, develops in length towards the apex of the fruit as the latter grows; the attachment with the small aborted ovules is now distinctly below its middle.

The embryo at this stage is suspended from the apex of the seed and shows a distinct, short, turbinate radicle, .5 mm. long, with fleshy, lenticular, diverging, subtransparent, exauriculate cotyledons 2 mm. long and 2.25 mm. wide. The endosperm occupying the basal part of the seed is also subtransparent, soft and in a semi-gelatinous condition.

*Pistil* enclosed in an involucre or cupule, composed of imbricating bracts firmly cohering by their bases; ovary of three carpels, three-celled, with two ovules in each cell; ovules pendulous, anatropous, from the top of the cell with a prominent, projecting, superior micropyle.

*Fruit* an acorn or glans, ovoid or oblong, flattened at its junction with the receptacle, and umbilicate at the apex with the remains of the styles springing from the middle of the hollow, smooth, glabrous, shining, pale green, ultimately brown; perianth adhering to the ovary and with it forming the pericarp; seed free within the pericarp. By early rupturing of the septa the fruit becomes one-celled and one-seeded as the remaining five ovules are not fertilised, but become firmly pressed to the base of the ovary cavity by the large growing seed.

*Seed* large, filling the pericarp, ovoid-oblong, slightly oblique at the base and blunt at the apex; hilum basal; raphe very short or none (longer in *Q. Ilex*, at least in a younger state when the base of the seed is very oblique or even produced to a point); chalaza very conspicuous, giving off strong, radiating, longitudinal, forking, branching and anastomosing nerves which vary considerably; radicle apical, short, and just protruded from the cotyledons.

*Endosperm* absent.

*Embryo* straight, large, entirely occupying and conforming to the whole interior of the seed, which again conforms to the fruit, fleshy, pale yellow; cotyledons broadly oblong or suboval, plano-convex, with their flattened faces firmly applied to each other, entire at the apex or slightly emarginate owing to a prominence of



FIG. 669.—*Quercus pedunculata*.

Diagram of acorn and seed, nat. size: *o*, aborted ovule (pendulous, anatropous); *a*, axis elongated to show its nature; *ch*, chalaza; *m*, micropyle.

the chalaza where it is attached to the embryo-sac, and most often with a shallow sinus, notched at the base of the inner face where the short radicle and small plumule are seated; plumule attached to the inner face of the cotyledons a little above the base.

### Seedling.

*Primary root and hypocotyl* very similar to those of *Q. Ilex*.

*Cotyledons* in every respect similar to *Q. Ilex*, remaining in the nut and auricled at the base.

Several of the primary leaves are reduced to scales. First green leaf obovate-oblong, bluntly and shallowly lobate at the apex.

Succeeding leaves obovate or obovate-oblong, irregularly lobed, with strong ascending nerves running into the irregular lobes, glabrous except on the midrib above and the principal nerves beneath where they are pubescent, pale green, often suffused with brown.

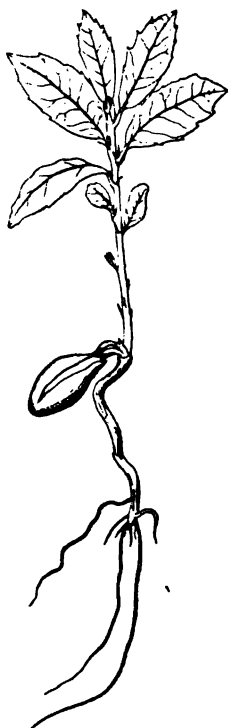


FIG. 670.—*Quercus Ilex*.  
Half nat. size.

### *Quercus Ilex*, L. (fig. 670).

*Primary root* long, woody, flexuose, tapering, dark-coloured, wiry.

*Hypocotyl* woody, subterranean, very stout, dark-coloured, flexuose, more or less distinct from the root.

*Cotyledons* subterranean, thick, fleshy, applied face to face in the testa, and convex on the back, longitudinally wrinkled, obovate-oblong in outline, retuse at the apex, petiolate and produced behind the petiole into a thin appendage; petioles both curved to one side of the stem, about 1.2 cm. long; lamina including auricle 2.25 cm. long, 1 cm. wide.

*Stem* woody, erect, terete, somewhat zig-zag from node to node, pale green, stellately pubescent, hoary when the tree attains some age; 1st internode 1 cm. long; 2nd-4th each about 1 mm.; 5th 5.5 mm.; 6th 2.5 mm.; 7th 1 cm.; 8th 1.75 mm.; 9th 5 mm.; 10th 2.5 mm.; 11th 2.5 mm.; 12th 3.5 mm.; 13th 2 mm. These lengths are liable to some variation in different seedlings, but they indicate the general tendency.

*Leaves* simple, cauline, alternate, stipulate, petiolate, evergreen, stellately pubescent on both surfaces, deep green and shining on the upper surface, ultimately glabrous there in the adult or old stage of the tree, and hoary with stellate pubescence on the under surface, penninerved, distantly serrate in the seedling stage, but nearly always quite entire in the adult tree; petioles short, terete, stout at the base, and tapering upwards, stellately pubescent; stipules linear-subulate, attenuate, dry, scarious, brownish, caducous.

Nos. 1-5. Small, scarious, brown scales.

No. 6. Very small, cuneate, tridentate at the apex.

No. 7. Small, oblong.

No. 8. Small, obovate.

No. 9. Lanceolate-oblong, distantly serrate, revolute and cartilaginous at the margin, 3.8 cm. long, 1.2 cm. wide.

No. 10. Elliptic-oblong, acute, distantly serrate.

Nos. 11-18. Elliptic-oblong, acute, acutely serrate.

The leaves of the typical form in the adult tree are oblong or ovate-oblong, acute, nearly always quite entire, revolute at the margin, deep green and shining above, hoary beneath with a stellate pubescence. *Q. Ilex* var. *serratifolia* has the leaves serrate even in the adult.

### *Castanea vulgaris*, Lam.

*Pistils* generally three together, enclosed in a four-leaved involucre covered with a dense mass of compound stellately-branching bracts; ovary of six to nine carpels, six- to nine-celled with two ovules in each cell; ovules pendulous, anatropous; micropyle superior, a little above the hilum.

*Fruit* a nut, at first six- to nine-celled, but soon becoming one-celled and one-, rarely two-seeded, ovoid, compressed on the inner side of the two lateral ones, and on two sides of the middle one, glabrous at the base externally but silky towards the top, and densely lined internally with silky white hairs. Involucre opening to allow the indehiscent fruits to escape.

*Seed* triangular-ovoid, usually deeply furrowed longitudinally on the ventral side, radiately nerved from the radicle or micropyle downwards and slightly anastomosing; raphe ventral; hilum near the apex on the ventral aspect, and below the radicle.

*Endosperm* always thin, transparent, jelly-like, occupying all the lower part of the seed while the embryo is young, but ultimately all absorbed by the embryo, leaving the seed exalbuminous.

*Embryo* straight, fleshy, transparent white, ultimately large, occupying the whole interior of the seed, and then milky white, or

yellowish externally; cotyledons from an early stage becoming concave, triangular or cucullate, conforming to the interior of the seed with the endosperm inside or between them. As they progress to maturity they develop along the base of the seed till they meet, with the last remains of the endosperm between them. They now become thicker, fleshier and more solid, wrinkled both externally and internally and undulate at the margin whereby they firmly interlock.

*Germination.*—The pericarp splits in the earth at the apex so that the shoot and rootlet can emerge and develop. The two large cotyledons rich in starch remain in the earth enclosed in the pericarp and are gradually absorbed. The first leaf is entire.

### ***Fagus sylvatica*, L.**

#### **EARLY DEVELOPMENT OF FRUIT AND SEED.**

*Pistil* of three carpels and three-celled in the early stage with very hairy loose dissepiments becoming easily detached from a central, filiform, placental axis, traversing the whole length of the ovary and bearing the ovules near the apex.

*Ovules* two in each cell, making in all six, pendulous, anatropous; raphe ventral; chalaza basal; micropyle superior, elongated and projecting into the neck of the cell below the base of the styles, and considerably beyond the attachment of the ovule; hilum ventral, a little below the apex of the seed.

After fertilisation and when the nut has attained its full size or nearly so, one ovule only begins to enlarge rapidly while the others become shrivelled and brown. This ovule is narrowly oblong, pointed at the micropyle and obtuse at the apical and lower end, with a distinctly prominent raphe and chalaza. Owing to the rapid development of the ovary, the ovule is very short even after the nut has nearly attained its full size.

When the young seed has grown about half the length of the ovary or more it becomes oblong and trigonous, in conformity with the interior of the ovary.

The coarsely hairy lines seen on each side of the placental axis correspond to the original septa of the primarily three-celled ovary.

The embryo has its cotyledons already folded once in conformity with the trigonous character of the fruit. A little later on the cotyledons get too wide for the cavity of the fruit, and, continuing to increase, their edges become doubled back in two of the angles of the seed, and the folds thus produced have the



effect of pushing the primary one right across the middle of the seed, and this position is retained permanently.

*Fruit* a one-celled, one-seeded nut, of which there are two to four, usually two, in an involucre, indehiscent, triquetrous, keeled from the top to below the middle, tipped with the hairy five- to six-lobed perianth and plumy remains of style, deep brown, shining, crustaceous, glabrous except at the top which is pubescent; by the early rupture of the septa the ovary becomes one-celled, while the axile placenta grows with it and equals it in length or nearly so. (Cf. *Quercus*.)

*Seed* strongly trigonous, or subtriquetrous conforming to the interior of the pericarp; testa thin, membranous, pale brown, marked with nerves proceeding from the chalaza to the micropyle, pendulous from the top of the cell, or rather from the placenta near the top; chalaza basal, distinctly elevated; hilum subapical or about 1 mm. below the apex, small; raphe long, running from the hilum along one face, or along one angle of the seed in a wavy manner.

*Endosperm* absent.

*Embryo* straight, large, entirely filling the seed when mature, and conforming to it in shape, colourless or pale yellow; cotyledons applied face to face, and plaited longitudinally, first with one large fold reaching from one angle of the cell to the middle of the flat face opposite, or in other words dividing the triangle in two equal halves; both cotyledons are then reversed on either side of the four folds forming the first division, and after proceeding backwards for some way are again turned forwards in the original direction, thus filling the other two angles of the seed.

*Seedling* (fig. 671).

*Primary root* long, stout, tapering downwards and after a time giving off freely short fibrous lateral rootlets.

*Hypocotyl* erect, stout, becoming more slender upwards, angled and furrowed, pale green, soon becoming brown, glabrous, 3-5.5 cm. long.

*Cotyledons* large, foliaceous, transversely oval, sessile, auricled at the base, with a fan-shaped venation, the nerves radiating and branching towards the margin from two main trunks, right and

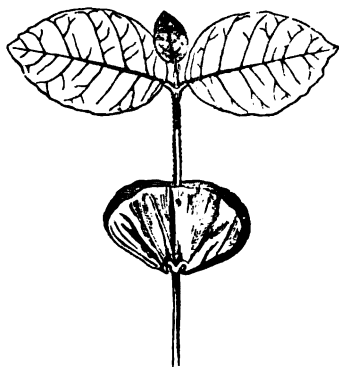


FIG. 671.—*Fagus sylvatica*.  
Half nat. size.

left of the axis of the plant, broadest along the upper edge and entire or obscurely crenate, glabrous, deep green above, white beneath, 1·7–3 cm. long, 3–4·7 cm. wide.

*Stem* erect, terete, hairy or pubescent when young, glabrescent, pale green, ultimately woody, arborescent; 1st internode 2·5–4·5 cm. long.

*Leaves* simple, cauline, alternate (first two opposite), stipulate, petiolate, alternately penninerved and finely reticulate, pubescent on both surfaces when young, glabrescent, shining on both surfaces, deep green above, paler beneath, deciduous; petioles terete,

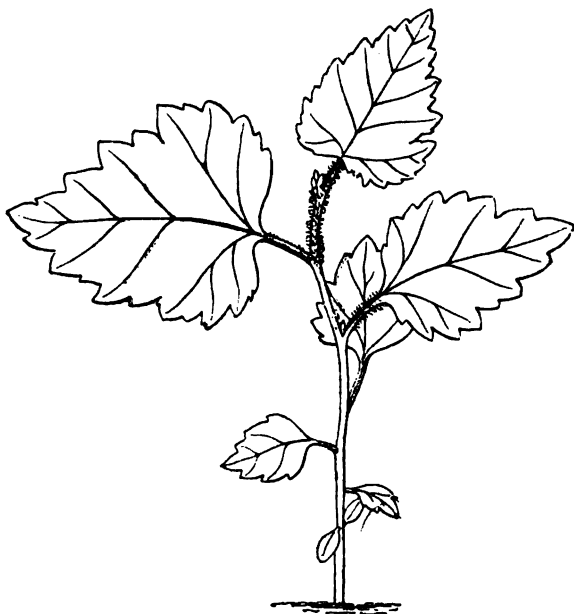


FIG. 672.—*Betula alba*. Nat. size.

or nearly so, slightly channelled on the upper side, densely hairy, at least when young, comparatively short; stipules oblong-obtuse, narrow, pale brown, scarious, hairy, caducous.

Nos. 1 and 2. Opposite, broadly ovate, obtuse, obtusely crenate-serrate.

No. 3. Alternate, broadly ovate, obtuse, entire or obsoletely crenate, much smaller than the first two.

This terminates the first season's growth.

***Betula alba*, L. (fig. 672).**

*Hypocotyl* erect, terete, pale green, densely pubescent, 8 mm. above the soil.

*Cotyledons* small, oblong-ovate, obtuse, petiolate; lamina glabrous, 3-4 mm. long, 2.5-3 mm. wide; petiole grooved above, rounded and pubescent on the back, 1.5 mm. long.

*Stem* woody, erect, terete, pubescent at the base, hairy upwards, ultimately with the bark peeling off longitudinally in stripes leaving the trunk white; 1st internode 4 mm. long; 2nd 6 mm.; 3rd 4 mm.; 4th 7 mm.; 5th 9.5 mm.

*Leaves* simple, cauline, alternate, stipulate, petiolate, alternately penninerved, glandular on both surfaces and hairy when in the young or seedling stage, ultimately glabrous and dotted with sessile glands on both surfaces, deep green above, pale beneath; petioles subterete, channelled above, densely pubescent in the seedling stage, glabrous in adult specimens after full development, slightly twisted so as to bring the surface of the leaf up to the light in pendent branches; stipules small, ovate or triangular, ciliate, caducous.

No. 1. Small, ovate, trifid, three- or obscurely five-nerved.

No. 2. Ovate, obtuse, serrate, five-nerved at the base, alternately penninerved upwards.

No. 3. Triangular, coarsely serrate.

No. 4. Triangular-ovate, coarsely serrate.

No. 5. Triangular-ovate, coarsely almost doubly serrate, subcuneate at the base.

No. 6. Cordate, acute, lobulate-serrate or doubly serrate.

Ultimate leaves ovate, acuminate, doubly serrate, subcuneate at the base, glabrous, glandular on both surfaces, fragrant.

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**SALICINÆ.**

Benth. et Hook. *Gen. Pl.* iii. 411.

*Fruit and Seed.*—The ovary is superior, and one-celled with two to four parietal placentas. The ovules are numerous, inserted in two or many series on the placentas below the middle of the ovary, ascending and anatropous. The fruit is capsular, and ovoid or oblong, dehiscing by two or four valves according

to the number of carpels of which it is composed. The seeds are numerous, small or minute, furnished with a dense coma of long, silky hairs arising from the funicle, and exalbuminous. The embryo is straight and conforms to the interior of the seed with oblong plano-convex cotyledons, and a very short inferior radicle.

*Seedlings*.—The cotyledons of *Salix repens* (fig. 678) are oblong-oval, petiolate, very small and show a midrib but indistinctly. The first leaf is lanceolate, subacute, entire, rounded at the base, one-nerved and exstipulate. Seeds sown in a greenhouse germinated in the remarkably short space of two days. The cotyledons of *S. cinerea* do not differ in any appreciable degree from those of its congener. The two primary leaves are ovate, entire, or show a small tooth on each side. The third one is oval, acute, and tapers to the base. The ultimate leaves vary between oblong, elliptic, and obovate. The seedlings were self-sown.

***Salix repens*, L. (fig. 678).**

*Hypocotyl* erect or ascending, terete, glabrous, pale green or reddish, 2.5–3 mm. long.



FIG. 678.  
*Salix repens*, × 3.

*Cotyledons* oblong-oval, obtuse, entire, petiolate, with an indistinct midrib, glabrous, light shining green; lamina 2.5–2.75 mm. long, 1.5–2 mm. wide; petiole semiterete, flattened above, thickened at its insertion on the stem, 1 mm. long.

*Stem* in the early seedling stage erect, terete, pale green, glabrous, ultimately decumbent or creeping, much branched, woody.

*Leaves* simple, cauline, alternate, exstipulate or stipulate, petiolate, alternately incurvinerved.

No. 1. Lanceolate, subacute, entire, rounded at the base, shortly petiolate, exstipulate, with a distinct midrib but no other discernible venation in the young state when fresh, deep shining green above, glaucous beneath, glabrous; petiole grooved above, convex on the back, short.

***Salix cinerea*, L.**

*Hypocotyl* a deep purple, 5 mm. long.

*Cotyledons* very similar to those of *S. repens*.

*Stem* shrubby, erect, terete, pubescent, deep purple; 1st internode 1·5 mm. long; 2nd and 3rd very short or undeveloped.

*Leaves* simple, cauline, alternate, stipulate, petiolate, greyish, pubescent above, densely so or tomentose beneath, alternately incurvinerved and reticulate, but most distinctly so beneath; petioles short, dilated at the base, somewhat channelled above, pubescent, brownish or purple; stipules small and rather variable, half reniform, revolute at the margin, pubescent or tomentose like the leaves, reticulate.

Nos. 1 and 2. Small, ovate, acute, entire or with a small tooth on each side.

No. 3. Tapering to the base, oval, acute.

Ultimate leaves variable, oblong-elliptic, or subobovate, or oblong-lanceolate, obtuse at the apex, or very shortly cuspidate, subundulate and revolute at the margin, the latter at least when dry, entire or distantly serrulate.

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## GNETACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 417.

*Fruit and Seed.*—There is no ovary in this Order, and the naked ovule has a double or triple coat, the outer one of which is fleshy or thin and fibrous and the innermost membranous and produced into a long, slender tube above the nucellus, exserted from the mouth of the outer coat and simulating a style. The nucellus is ovoid or conical, solid or nearly so before fertilisation, but after that less solid. The seed is drupaceous or membranous and compressed, erect, and contains a thin or moderately thick layer of endosperm. The embryo is straight with the cotyledons longer or shorter than the radicle.

One type of the Order is represented by *Ephedra altissima* (fig. 675). The fruit consists of an ovoid or conical seed enclosed in a tubular, red cup consisting of two connate bracts, free at the tips and leaving an opening between them beyond which the seed projects. At the base of this cup externally are two much shorter and decussating pairs of connate bracts. The outer coat of the seed is crustaceous and

the inner membranous. The embryo is as long as the endosperm and has two linear-oblong, plano-convex cotyledons about twice the length of the superior radicle.

*Seedlings.*—The seedlings of three or four species of *Ephedra* coming under my observation are very similar, the chief differences consisting in the length of the cotyledons and the primary leaves. During the germination of *Ephedra altissima* the testa splits longitudinally and may or may not be carried up by the cotyledons as they rise above ground and straighten. The cupular process observed lying over the tip of the radicle in the seed seems designed to fix the latter in the ground during germination while the cotyledons rise up free. It is then seen to form a tubular sheath surrounding the base of the radicle and attached to the empty testa which is by that means pinned to the ground. Sometimes the attachment becomes broken and the testa is carried up on the tips of the cotyledons where it sometimes remains for a considerable time. The cotyledons are linear, emarginate, plano-convex, erect, but often much undulated or twisted by unequal growth or by their efforts to get out of the seed, slightly connate at the base, 3.1–5.7 cm. long and 1.5–2.25 mm. wide. The primary leaves are opposite, decussate, connate at the base, and the first four pairs are often unequal in length and vary from subulate to linear, similar to, but much shorter than the cotyledons. The cotyledons of *E. fragilis* differ but slightly from those of *E. altissima*, the chief distinctions being that they are acute, straight and 5–7 cm. long. The first node of the stem above the cotyledons bears three leaves in a whorl.

The cotyledons of *Ephedra vulgaris* (fig. 674) are linear, slightly channelled above, 3.1 cm. long and 1 mm. wide. The leaves are opposite and decussate, ovate, obtuse, connate at the base, very small and scale-like, and being so from the first pair onwards, they offer a marked contrast to those of *E. altissima*. The stem has a jointed appearance like that of *Casuarina* or *Equisetum*. The cotyledons of an unnamed species of *Ephedra* from Afghanistan are linear, semiterete, obtuse, grooved on the upper surface, slightly connate at the base, and otherwise closely resemble those of *E. vulgaris*.

***Ephedra vulgaris*, Rich. (fig. 674).**

*Hypocotyl* tapering downwards into the radicle, brown when old.

*Cotyledons* two, linear, obtuse, slightly channelled above, glabrous, glaucous-green, 8.1 cm. long, about 1 mm. wide.

*Stem* shrubby, diffuse, terete, striate, finely scabrous on the ridges, glabrous, deep green; 1st internode 9–13 mm. long; 2nd 1.3–1.5 cm.; 3rd 1.8–2.2 cm.

*Leaves* very small, cauline, opposite, decussate, sessile, ovate, obtuse, connate at the base, convex on the back, glabrous, pale green, thick and subfleshy when young, and entirely enclosing the

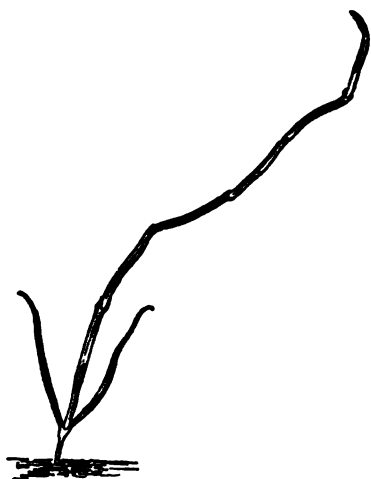


FIG. 674.—*Ephedra vulgaris*.  
Two-thirds nat. size.

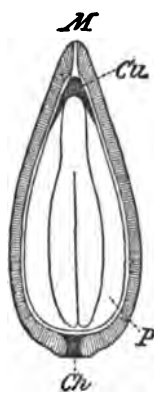


FIG. 675.  
*Ephedra altissima*,  $\times 5$ .  
Longitudinal section of seed  
through the cotyledons: *M*,  
micropyle; *Cu*, cupular  
process of loose tissue; *P*,  
endosperm; *Ch*, chalaza.

growing tip in bud, becoming pale or brown and scarious at an early age, persistent, ultimately torn by developing axillary buds.

***Ephedra altissima*, Desf. (fig. 675).**

*Ovule* enclosed in a tubular, shortly bifid, glabrous, pale red envelope, and that again in two successively smaller envelopes, erect, terminal, orthotropous; micropyle superior.

*Seed* enclosed in the tubular processes above-mentioned, each of which consists of a pair of connate, opposite, decussate bracts. Sometimes there is present the remains of a second aborted ovule. Narrowly and pointedly ovoid-conical, glabrous, brown, obsolete four-ribbed towards the apex; testa thick, crustaceous and tough; tegmen very thin, membranous, brown, more or less exerted as a

styliform process when in a young state ; hilum and chalaza basal ; micropyle apical.

*Endosperm* copious, fleshy, white, embedding the embryo, except at the tip of the radicle, and forming only a very thin layer round the apex of the cotyledons.

*Embryo* straight, nearly as long as the cavity of the seed, comparatively large, lying in the axis of the endosperm ; cotyledons two, oblong-linear, obtuse, entire, fleshy or thick, plano-convex, closely applied face to face in the seed, about twice as long as the radicle ; radicle stout, oblong, terete, very obtuse, slightly constricted in the middle with the upper half white like the cotyledons and the lower half yellow, lying in a cup-like process of loose tissue close to the micropyle.

### *Ephedra fragilis*, Desf.

*Hypocotyl* as in *E. altissima*, 1-2.5 mm. long.

*Cotyledons* linear or acicular, fleshy, 5-7 cm. long, glabrous, acute, green.

*Stem* erect, terete, herbaceous, ultimately woody ; 1st internode 1-1.5 mm. long.

*First leaves* three in a whorl, simple, entire, cauline, linear, acute, glabrous.

An undetermined species of *Ephedra*, from Afghanistan, has very similar cotyledons.

### Seedling.

*Primary root* long, tapering downwards, copiously furnished with root-hairs, without lateral rootlets till it attains some size, tipped in the seed by a cup-like process which forms a sheath to it after germination.

*Hypocotyl* erect, terete, glabrous, green, 8.5-12.5 mm. above the soil, stout, and fleshy at first.

*Cotyledons* long, linear, emarginate during or after germination, and generally more or less discoloured at the tip, semiterete, flat above or slightly grooved, rounded on the back, deep green and often distinctly glaucous, glabrous, often twisted or variously bent in making their escape from the seed, connate at the base and forming a cupule round the plumule, not differentiated into lamina and petiole, erect with spreading tips for a long time at least after completing germination, 8-15.7 cm. long, 1.5-2.25 mm. wide.

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## CONIFERÆ.

Benth. et Hook. *Gen. Pl.* iii. 420.

*Fruit and Seed.*—The ovules are naked, solitary, or vary from two to several collaterally inserted near the base, rarely under the apex of an ovuliferous scale in the axil of a bract; they are superficial or partly submersed in the tissue of the scale and erect or reversed with the micropyle superior or pointing to the base of the scale accordingly. The fruit is usually a cone consisting of closely imbricating scales covering the seeds; but in many species of the tribes Taxæ and Podocarpeæ, and in *Cephalotaxus* the scales remain small while the large, solitary seed projects considerably beyond them. The seed is ovoid or oblong with a membranous, fleshy or crustaceous testa sometimes winged at the sides or again at the apex. Endosperm is copious and fleshy or farinaceous, and remarkably ruminated in *Torreya*. The embryo is straight and axial with two, three or many cotyledons, usually shorter than the radicle.

*Pinus Pinaster* may serve as a type of the Order. The seeds are winged at the upper end, the wing being produced by delamination from the inner layer of the ovuliferous scale. The outer layer of the testa is thick and woody while the inner one is membranous. The embryo is clavate, and straight, with six to seven or more cotyledons which are trigonous, obtuse and several times shorter than the cylindrical radicle.

*Seedlings.*—The cotyledons vary greatly in different genera, and in the different species of *Pinus*, *Abies*, and *Picea* the number varies even in individuals. They also vary more or less in shape dependent upon their number, in the same way as in the secondary leaves of *Pinus*. When there are only two they are flat or plano-convex, but when more numerous they are trigonous, triquetrous, or form some segment of a cylinder.

The cotyledons of *Taxus baccata* (fig. 677) are linear, obtuse, flat, or slightly plano-convex, two in number, 1·7 cm. long, and 2 mm. wide. The primary leaves are opposite or

nearly so, spreading, decussate, and nearly flat. The first pair are lanceolate-linear and acute; the next two pairs are linear and subacute; while the fourth and fifth pairs are linear, cuspidate, and unequal in size, as if really alternate and scattered, and such in fact may be the case. The leaves of lateral branches in the seedling resemble those of the adult in being scattered with a distichous arrangement, while the phyllotaxy remains the same. On ascending or upright shoots they ascend in various directions, and are not bifariously arranged. All have a distinct midrib seen on both surfaces, but more prominent on the upper, are distinctly petiolate, and arise from a linear-oblong, elevated pulvinus or process adnate to the shoot.

The cotyledons of *Thuja occidentalis* are linear, acute, tapered to the base, one-nerved, flat or nearly so, and two in number. The two first leaves are opposite, spreading, similar to, but smaller than the cotyledons, and are followed by five or more whorls of three similar ones. In some cases one of the three is inserted at a slightly higher level than the rest, or they may even all be scattered with a spiral arrangement. The ultimate leaves are opposite, decussate, and adnate for great part of their length to dorso-ventrally flattened shoots. The cotyledons of *Thuja gigantea* (fig. 676) conform to the above type. The first four leaves are in opposite pairs decussating with the cotyledons, and are followed by a number of whorls or pseudo-whorls, of similar but longer and more decidedly acicular leaves. Above the first dozen or so of whorls, lateral branches are given off bearing sometimes a few acicular and spreading leaves at their bases, while succeeding leaves are imbricate and decurrent, gradually giving place to closely imbricate and decurrent leaves, arranged in four rows and decussate. The branches are then horizontal or drooping, and dorso-ventrally flattened.

*Cryptomeria japonica* differs from the above-mentioned species in having two to three linear, obtuse cotyledons flat above and slightly convex beneath. Out of fifteen seedlings examined, twelve had three cotyledons. The testa is very frequently carried up on the tips of the cotyledons during germination, but is ultimately thrown off by their bulging

or bending out. It opens at the apex only to allow of the exit of the embryo.

The second well-defined type of cotyledons is met with in *Pinus rigida* (fig. 678). Here they are acicular, obtusely trigonous, acute and slender at the tips, four to six in number, and ultimately attain a length of 1.4–1.6 cm. They carry up the testa during germination, and push themselves out at an apical opening, first by the mere process of elongation, but afterwards get rid of the testa in the same way as *Cryptomeria japonica*. The primary leaves of the seedling are acicular, densely and spirally arranged on the axis. The primary ones of the adult are reduced to brown scales, while the secondary are arranged in fascicles of three in their axils, and are three to four inches long. The cotyledons of *Pinus sylvestris* vary from five to ten in number, and are acicular, serrulate at the margins, variously angled and compressed. Those of *Pinus halepensis prolifera* are acicular, trigonous, acute, 3–4 cm. long, and vary in number from seven to nine. *Picea orientalis* agrees very closely with *Pinus* and has six to ten acicular, attenuate cotyledons, obtusely trigonous and distantly ciliate-serrulate at the margins. They make their exit from the testa in the same way as in *Pinus rigida*, and when full grown radiate horizontally with their tips curved in one or two directions. When about half-grown and still surmounted by the testa they curve outwards regularly in the form of a balloon. The crustaceous testa splits longitudinally, but the surrounding endosperm remains intact except at the point of exit at the micropyle, forming a sheath to the cotyledons.

*Actinostrobus pyramidalis* may be placed here, as although it has only three cotyledons, they are linear-subulate, subtriquetrous, and 9 mm. long. The primary leaves are similar to the cotyledons in outline, and verticillate in whorls of three, but are biconvex, decurrent upon the axis, and cover the whole of the internodes with the free portion 8–13.5 mm. long.

*Actinostrobus pyramidalis*, *Miq.*

*Hypocotyl* woody, erect, terete, glabrous, brownish, about 7–10 mm. above the soil.

*Cotyledons* three, linear-subulate, acute, subtriquetrous, glabrous,

glaucous-green, spreading or arching, with the broadest face towards the soil, and one on each side of the median ridge on the upper surface, 9 mm. long.

*Stem* woody, erect, glabrous, glaucous, obtusely three-ridged and shallowly three-furrowed owing to the adherent or decurrent bases of the leaves; 1st internode undeveloped; 2nd 5 mm. long; 3rd 4.25 mm.; 4th 5.25 mm.; 5th 6 mm.; 6th 5 mm.; 7th 6 mm.; 8th 5.5 mm.; 9th 4 mm.

The primary leaves are simple, entire, cauline, verticillate in whorls of three, linear-subulate, acute, horizontal, compressed horizontally, and convex on both surfaces, decurrent or adnate by their faces to the stem, and covering the whole internodes with the free part, 8–18.5 mm. long, deep glaucous-green above and paler beneath.

*Thuja gigantea*, Nutt. (fig. 676).

*Primary root* long, woody, flexuose, brown, with a few long brownish fibres.

*Hypocotyl* woody, erect or suberect, terete, about 1.5 cm. long, 1.5 mm. thick, brown.

*Cotyledons* two.

*Stem* woody, terete and smooth near the base, ridged higher up from the decurrent sessile leaves, brownish-green.

*Leaves* of two kinds, with intermediate stages.

(a) Acicular leaves in more or less true whorls, decurrent except the few lowest, which are only 2–3 mm. long by .75 mm. wide, and yellowish-green, whilst the upper ones are 1 cm. long, 1.5 mm. wide, prominently decurrent, sharply pointed, and dull dark green above with a lighter tint and white midrib on the lower surface.

After about a dozen pseudo-whorls, the first branch is formed and may or may not bear a few acicular leaves, passing gradually or suddenly into the second predominating form.

(b) Scale-like, imbricate leaves as in *Thujopsis dolabrata*, &c.<sup>1</sup>

*Thuja occidentalis*,<sup>2</sup> L.

*Primary root* tapering downwards with a few fibrous lateral rootlets.

<sup>1</sup> Tuberf, l. c. p. 108, figures and describes the same species and says of the cotyledons, 'about 6 mm. long, and 1-1.5 mm. wide, broadly pointed, green on both surfaces, midrib scarcely visible.' He also (p. 102) figures and describes *Thuja japonica*, which differs from *T. gigantea* in having broader cotyledons, and the primary leaves in opposite decussate pairs. The seeds of these two species are also described (p. 31).

<sup>2</sup> Cf. Tuberf, l. c. p. 101 (with figure of a very young seedling). The cotyledons are described as about 8 mm. long, by 1 mm. wide.

*Hypocotyl* erect, quadrangular, glabrous, 5 mm. long, light green.

*Cotyledons* two, linear, acute, entire, sessile, slightly tapering towards the base, glabrous, light green, one-nerved.

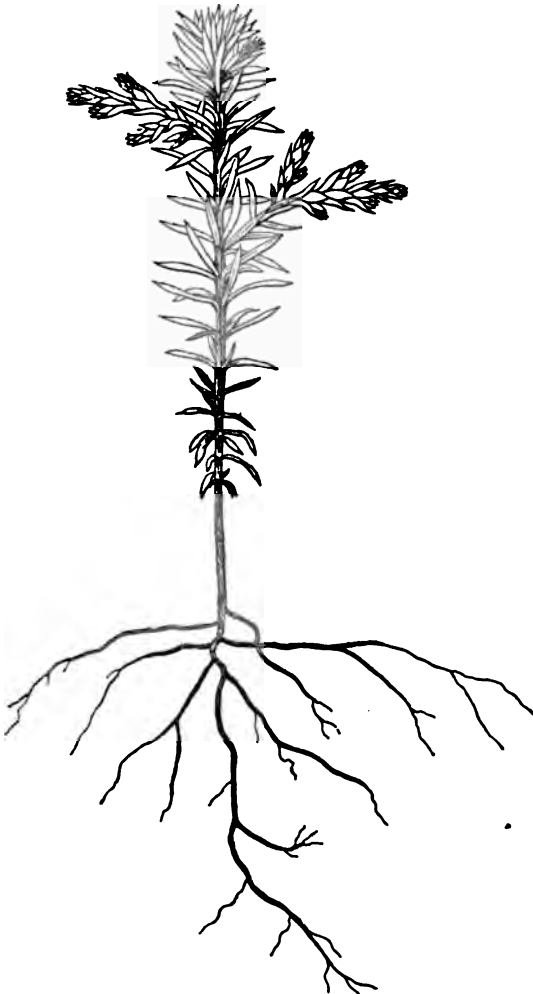


FIG. 676.—*Thuja gigantea*. Nat. size.

*Stem* ascending, herbaceous, ultimately woody, quadrangular, light green; 1st internode very short; 2nd and following ones considerably longer.

*Leaves* cauline, opposite and verticillate, arranged in whorls of three, though in some plants they seem to be in pairs with the odd one slightly higher, or have even a spiral arrangement, linear, acute, sessile, exstipulate, glabrous, light green, one-nerved.<sup>1</sup>

In all the Junipers and Thujas the young plants have needle leaves. In many species of the Cupressineæ the subsequent foliage is flattened; and in some the two tendencies are so nearly balanced that even on the same branch some twigs bear acicular, some flattened, leaves. The former seem to be especially developed on the lower and inner branches.

***Cryptomeria japonica*, Don.**

*Primary root* tapering downwards, somewhat flexuose, pointed, colourless, unbranched in its early stage.

*Hypocotyl* erect, terete, glabrous, pale green, slightly stained with red at the base, 1-1.6 cm. above the soil.

*Cotyledons* two to three, linear, obtuse, flat above and deep glaucous-green, slightly convex beneath and paler, 6.5-8 mm. long, 1.5-2 mm. wide. Out of seventeen seedlings three had two cotyledons, twelve had three cotyledons, and two were not sufficiently advanced to determine the number.

*Stem* erect, ultimately woody; primary internodes undeveloped; ultimate ones very short.

*Leaves* simple, entire, cauline, spirally arranged on the stem and close together, exstipulate, sessile, decurrent, linear-falcate, ascending towards the apex of the branches, three- to four-angled with the posterior or dorsal angle strongest and decurrent on the stem or branch, glabrous, deep glaucous-green.

Nos. 1-3. Following each other closely, often appearing verticillate and alternating with the cotyledons.<sup>2</sup>

***Taxus baccata*, L. (fig. 677).**

*Primary root* tapering, fleshy, colourless, giving off very few lateral fibres in its early stages.

<sup>1</sup> Tabeuf, l. c. p. 108, describes and figures (fig. 143), the seedling of *Thujaopsis dolabrata*, which resembles that of *Thuja gigantea*, but has broader, very blunt cotyledons. The primary leaves are also shorter and broader.

*Biota orientalis*, l. c. p. 104 (fig. 144), has two much larger cotyledons, 2.2-2.5 cm. long, 1.5-2 mm. wide, but is otherwise at first very similar.

<sup>2</sup> *Vide* Tabeuf, l. c. p. 97, where is a figure of a seedling and also of a two-year-old plant. The seeds are described on p. 82.

*Hypocotyl* erect, terete, glabrous, green, finely striate, soon becoming woody, 2·8–3·9 cm. long.

*Cotyledons* two, linear, obtuse, glabrous, 1·7 cm. long, 2 mm. wide.

*Stem* erect, suffrutescent and soon becoming woody, subangular, glabrous, green; 1st internode 2 mm. long; 2nd 3 mm.; 3rd 1·5 mm.; 4th ·5 mm.

*Leaves* simple, entire, cauline, exstipulate, sessile, opposite in the seedling state, but the pairs at the growing point develop unequally, as if alternate, glabrous, persistent, deep green above, paler beneath, with a prominent midrib on both faces.

First pair lanceolate-linear, attenuate, acute, 1·7 cm. long.

Second and third pairs linear, subacute.

Fourth pair linear, cuspidate.

Fifth pair linear, cuspidate, very unequal in size, the shorter one not half the length of the other, at least while young and still growing.

Ultimate leaves alternate or scattered, arranged distichously in a double row on each side of the branches with the upper faces all turned in one direction, and articulated with a linear-oblong, cushion-like piece, adnate to the branches; upper series of leaves shorter than, and alternating with the series beneath it; leaves linear, straight or falcate, acute or cuspidately acute, persistent, deep green above, paler beneath, especially when young, with a prominent midrib on both surfaces, and a very pale line on each side of the midrib beneath.

#### *Pinus Pinaster*, *Soland.*

*Ovary* consisting of an open carpel on the base of the inner face of which two ovules are seated on a process termed an ovuliferous scale; ovules reversed, adnate to the scale in the early part of the season; micropyle inferior.

*Fruit* a cone consisting of scales spirally arranged in many series. The carpellary scales do not increase after fertilisation, remaining small, and membranous; but the inner seminiferous scales



FIG. 677.—*Taxus baccata*.  
Nat. size.

become large and woody, thickened at the end, densely imbricating and each containing at the base of the inner face two large winged seeds resembling samaras. Scales persistent, ultimately separating to allow the seeds to drop out.

*Seed* obovoid, dorso-ventrally compressed and winged at the top; after removal of this wing the margins are seen to be drawn out into two thin edges, or incipient wings; seed-coat after removal of the wing consisting of two layers, the outer one of which is thick, hard, and woody, comprising a thin outer dark brown or black stratum, and a pale brown, much thicker inner stratum; the inner layer is pale brown and black at the radical end of the seed, thin and membranous, but capable of being broken or split up into two thinner strata; micropyle inferior; chalaza superior.

*Endosperm* copious, white, subfarinaceous, surrounding the embryo.

*Embryo* central, large, straight, nearly equal in length to the endosperm, colourless; cotyledons six to seven, packed together in a clavate mass, linear-oblong, obtuse, trigonous, several times shorter than the radicle; radicle and hypocotyl together stout, cylindrical, abutting against the remains of the suspensors at the base of the seed and close to the micropyle.



FIG. 678.—*Pinus rigida*,  $\times 2$ .

*Pinus rigida*, Mill. (fig. 678).

*Primary root* tapering downwards, subflexuose, unbranched for some time after germination.

*Hypocotyl* erect, terete, glabrous, deep glaucous-green, and more or less stained with red near the base, 8–18 mm. above the soil.

*Cotyledons* four to six, acicular, obtusely trigonous, attenuately acute and slender at the tip, glaucous-green, glabrous, straight in the seed, but during germination pushed out by their own elongation, bulging out all round, and finally pulling themselves out of the seed, after which they gradually spread out to the light, attaining a length of 1.4–1.6 cm.<sup>1</sup>

*Stem* erect, woody.

*Leaves* dimorphic, simple, cauline, sessile, exstipulate, glabrous.

<sup>1</sup> Tubeuf, l. c. p. 86, says: 'The plant has lost its cotyledons by the beginning of the second year.'



Primary ones small, scale-like, hyaline, spirally arranged in many series, more or less deciduous.

Secondary ones acicular, acute, fascicled in clusters of three in the axils of the primary scarious leaves, evergreen, and persisting several years.

The first leaves of the seedling are numerous, alternate, densely and spirally arranged, plano-convex and acicular.

***Pinus sylvestris*, L.**

*Primary root* long, tapering but slightly, rather fleshy, subflexuose, unbranched in the early stage.

*Hypocotyl* glabrous, pale green, about 4.4 cm. long.

*Cotyledons* ten (in specimen described), whorled, ascending, acicular, acute, distantly serrulate at the margins, semiterete and flattened above or variously compressed, and angled by mutual pressure, deep subglaucous-green, forming a vasiform cupule around the plumule.<sup>1</sup>

***Pinus halepensis*, Mill., var. *prolifera*.**

*Hypocotyl* covered with a fine bloom, purplish-green, 3-4 cm. long.

*Cotyledons* seven to nine, acicular, trigonous, 3-4 cm. long, acute, covered with a fine bloom, glaucous-green.<sup>2</sup>

***Picea orientalis*, Carr.**

*Primary root* tapering downwards, and some time after germination very much elongated, flexuose with a few very short scattered lateral rootlets.

*Hypocotyl* erect, terete, glabrous, striate or shallowly ridged and furrowed, the furrows opposite to or running down from the back of the cotyledons, and the ridges corresponding to their united and decurrent edges, 1.8-3.2 cm. long, slender, pale green or ultimately straw-coloured, slightly twisted.

*Cotyledons* six to ten, acicular, attenuately acute at the tip,

<sup>1</sup> Cf. Tübenf., l. c. p. 83, fig. 110; the cotyledons are described as mostly six in number (4-7), to 2 cm. long, with two resin canals, and the primary leaves as serrate on both edges, and spiral with no resin canal. The cotyledons die in the winter and hang on the plant till spring.

<sup>2</sup> Tübenf., l. c. pp. 82-88, describes also *P. montana*, fig. 111 (very like *P. sylvestris*); *P. Laricio*, fig. 112 (cotyledons 6-8); *P. Thunbergii* (cotyledons 6-8); *P. Pinaster*, fig. 113 (cotyledons 7-9); *P. Pinea*, fig. 114 (cotyledons 10-13, about 6 cm. long); *P. ponderosa*, fig. 115 (cotyledons 9); *P. Jeffreyi* (cotyledons 10, up to 5 cm. long); *P. Cembra*, fig. 116 (cotyledons 9-12); *P. Strobilus*, fig. 117 (cotyledons 8-11); *P. excelsa*, fig. 118 (cotyledons 9-11).

obtusely trigonous, distantly and minutely ciliate-serrulate, deep subglaucous-green, straight in the seed, emerging as in *Pinus*, finally radiate and straight, or more or less twisted or curved in one or two directions, 1.1–1.7 cm. long.

*Plumule* covered with a cap of scales the outer of which are pale brown, the inner smaller, more numerous and hyaline.

*Stem* erect, ultimately woody.

*Leaves* simple, entire, cauline, acicular, spirally scattered, obtusely tetragonous, narrowed at the base into a very short petiole and jointed to a little pulvinus on the branches, deep green, very short.<sup>1</sup>

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## CYCADACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 443.

*Fruit and Seed*.—The male and female flowers are arranged in separate cones in most genera ; those bearing the ovules are generally the thicker. The scales are closely imbricated and spirally arranged ; in the case of *Cycas* they are greatly elongated and bear the ovules alternately on the lateral margins. They, in fact, resemble aborted leaves densely covered with rusty brown hairs. In other genera the scales are very short, much thickened, peltate and bear a single orthotropous ovule on each side pointing towards the axis. The testa is single and produced into a short tube at the micropyle. The seed is large, variable in shape, and often variously angled. The outer layer of the testa is orange or red, and the inner crustaceous or bony. Endosperm is copious and fleshy, embedding the subcylindrical embryo in its upper part ; and the cotyledons are conferruminate or amalgamated in one piece, or free at the base only to permit the exit of the plumule.

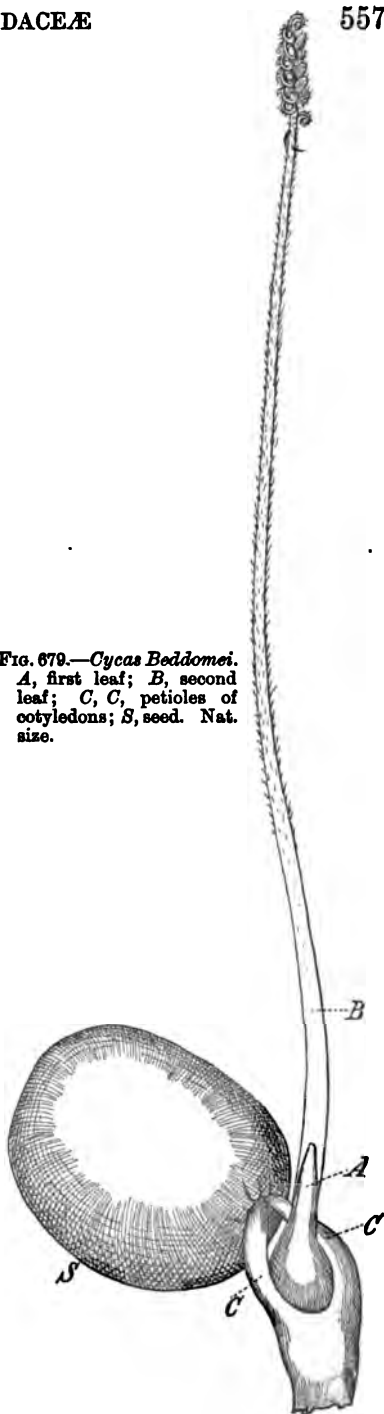
*Seedlings*.—As the seeds are large in nearly all the genera of the Order and differ in this respect from the Gnetaceæ and Coniferæ, so I find that in all the seedlings observed the coty-

<sup>1</sup> Tubeuf, l. c. pp. 90–92, describes seedlings of *Picea excelsa*, fig. 121 ; *P. alba*, fig. 122 ; *P. polita*, *P. orientalis*, fig. 123 ; *P. Alcockiana*, fig. 124 ; *P. Omorica*, *P. sitchensis*, fig. 126 ; all of which bear a general resemblance to that of *P. orientalis*.

ledons are subterranean, and remain in the seed till the endosperm is absorbed, when they decay. Another peculiarity is that the plumule consists of a mass of stout, fleshy scales resembling a resting or winter bud, which emerges from the fissure at the base of the cotyledons during germination. A solitary perfect leaf is soon after developed from the centre of the bud as seen in *Zamia integrifolia*. This leaf consists of two pairs of leaflets, crowded together at the apex of the petiole; the terminal pair is much the smaller, and all have numerous, longitudinal, parallel nerves.

The seed of *Cycas Beddomei* (fig. 679) is globose-oblong, and the bud formed by the plumule is rather small, consisting of one or two scales. The method of germination corresponds to that of *Zamia integrifolia*. The primary perfect leaf is pinnate with eleven to nineteen linear, entire leaflets having a distinct midrib only. *Dioon spinulosum* has a comparatively large, oblong seed and a large bud of four scales. The first leaf is finely pec-

FIG. 679.—*Cycas Beddomei*.  
A, first leaf; B, second leaf; C, C, petioles of cotyledons; S, seed. Nat. size.



tinate or pinnate with twenty-three to twenty-five spiny-serrate leaflets, the veins of which are longitudinal, slender, and numerous. In all three cases the leaflets are circinate in veneration like most Ferns.

***Cycas Beddomei*, Dyer (fig. 679).**

*Primary root* very long, stout, fleshy, colourless, giving off a few short lateral rootlets after a time.

*Hypocotyl* very short, stout, subterranean, passing somewhat abruptly into the root.

*Cotyledons* two, subterranean, and remaining in the seed till they decay, petiolate; petioles stout, fleshy, semiterete, sufficiently long to allow the plumule to make its exit between them during germination.

*Stem* short, erect, woody, and of very slow growth, undeveloped for some considerable time after germination.

*Leaves* radical, ultimately all cauline, pinnate, alternate, exstipulate, petiolate, pilose when young particularly on the midrib beneath, evergreen, subcoriaceous; pinnæ linear, acute, entire with a distinct midrib but no other visible venation, circinate in veneration; petiole downy when young, ultimately glabrous, terete. First leaf, and sometimes the second, or even the third reduced to a large, subulate, semiterete, fleshy scale, without leaflets. Second leaf usually foliaceous with eleven to nineteen linear, entire leaflets.

***Zamia integrifolia*, Ait.**

*Cotyledons* two, remaining in the seed, subterranean.

*Stem* erect, ultimately woody, of slow growth, and consequently short; internodes undeveloped.

*Leaves* caespitose, pinnate; leaflets notched at the apex, sessile, almost linear but rather tapering towards the base, light green at first then dark green, glabrous, with parallel veins.

Primary leaves reduced to short scales closely investing the plumule, and owing to the undeveloped condition of the internodes resembling a resting or winter bud. First true leaf with two pairs of linear-spathulate, somewhat oblique leaflets; petiole thinly hairy, green, soon becoming brown.

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HYDROCHARIDEÆ.<sup>1</sup>Benth. et Hook. *Gen. Pl.* iii. 448.

*Fruit and Seed.*—The ovary is inferior, one-celled, with three to six placentas, rarely fewer or more, parietal or projecting into the centre of the cavity without uniting; ovules several on each placenta, pendulous or, especially the lower ones, ascending, anatropous or sometimes orthotropous. The fruit is submerged, globose, ovoid, oblong or linear, dry or more or less pulpy, bursting irregularly through swelling of the jelly-like contents, or opening by decay of the pericarp; one- or six- to many-celled by coalescence of the placentas in the centre; pericarp membranous or rarely somewhat fleshy. The seeds are numerous, oblong; the outer layer of the seed-coat consists of spirally thickened cells, swelling up and becoming mucilaginous in water; the inner layer is usually hard and more or less crustaceous, as in *Stratiotes*, and especially in *Blyxa*, where it is sculptured and almost bony. In some species, as *B. echinosperma*, the testa has thorny prolongations. The seeds are small in the *Vallisneriæ*, *Blyxa* and the *Otteliæ*, larger in the other tribes. They are exalbuminous, the embryo completely filling the seed.

In the freshwater genera the hypocotyl coheres with the cotyledon into a more or less oval mass, including the small plumule at the base of a lateral cleft. As examples, compare *Lagarosiphon muscoides*, figured by Caspary,<sup>2</sup> who says 'the embryo has a very strong resemblance to that of *Naias major*, *minor*, and *flexilis*, and gives an indication of the systematic position of the *Hydrillæ*.' *Vallisneria*, *Ottelia*, and *Hydrocharis* also follow this type. The embryo terminates in a small radicle.

*Stratiotes* is exceptional among the freshwater genera. Here<sup>3</sup> the cotyledon is distinct from the hypocotyl, linear-

<sup>1</sup> In this and some of the following Orders I have no observations to record. It may still, however, be convenient, for purposes of reference, to give a short description of the fruit and seed.

<sup>2</sup> *Die Hydrillen*, in *Pringsh. Jahrb.* i. 478.

<sup>3</sup> *Irmisch, Flora*, 1865, p. 81, t. 1.

lanceolate in outline, and only slightly sheathes the plumule with its edges at the base. The plumule is large and exceptionally well developed, including eight to ten young foliage leaves, of which the outer ones sometimes reach to the apex of the cotyledon. The fleshy conical hypocotyl is about a quarter the length of the cotyledon, and there is no trace of any radicle.

In *Halophila* and *Thalassia*, which inhabit the sea, the embryo consists of a strongly developed lower hypocotyledonary, or hypocotyledonary and radicular portion bearing a very distinct but much smaller cotyledon which sheathes the plumule. In *Halophila*<sup>1</sup> the lower part consists entirely of hypocotyl, the radicle being absent as in *Stratiotes*. In *Thalassia Hemprichii* we find according to Solms<sup>2</sup> an 'extraordinarily large stem and root portion' filling the whole under part of the seed, in the apex of which is the small cotyledon and strongly developed plumule. Embryos such as these are termed macropodous (large-footed).

*Stratiotes aloides*,<sup>3</sup> L.

*Fruit* a capsule, six-celled, unequally angled, mucous.

*Seeds* anatropous, in the angle of the thick outer and the thin inner wall, almost erect; raphe towards the centre of the fruit; micropyle and hilum contiguous and directed towards the outside wall. Rather long, slightly verrucose, and with a slight carina; testa hard; tegmen very thin.

*Endosperm* absent.

*Embryo* unusually far developed, including eight to ten young foliage-leaves spirally arranged, forming the plumule; cotyledon linear-lanceolate, thick, fleshy, only very slightly embracing the plumule with its edges at the base, its apex rounded or pointed and the outer leaves of the plumule sometimes reaching the apex, sometimes shorter; in its axil and also in that of the outer foliage-leaves are two small scales (squamulae intra-axillares); hypocotyl fleshy and conical, about one-fourth the length of the cotyledon and bearing at the end a particle of dead tissue, the remains of the suspensor; radicle absent. A longitudinal section of the hypocotyl shows

<sup>1</sup> J. B. Balfour, *Trans. Bot. Soc. Edinburgh*, xiii. (1879).

<sup>2</sup> Solms-Laubach, in *Schweinfurth, Flora Aeth.* p. 195.

<sup>3</sup> Cf. Klinsmann, *Bot. Zeit.* 1860, p. 81, taf. ii.; and Irmisch, *Flora*, 1865, p. 81, t. 1.

the commencement of a lateral root beneath the growing point of the plumule.

*Germination*.—The hard brittle seed-coat splits from the micropylar end upwards, but often remains for a time entire at the opposite end, seated on the tip of the cotyledon, but sooner or later the two halves fall apart. The delicate colourless tegmen remains inside the brown testa. The cotyledon quickly elongates, without any considerable increase in thickness, to three-quarters to one inch, it is semiterete, shallowly grooved above at the base, while the apex is thinner and usually bent upwards; colourless at first, but soon becoming green like the foliage-leaves. The hypocotyl is coloured like the cotyledon, and like it undergoes no striking change, merely elongating somewhat.

The leaves of the plumule soon bend downwards, and get longer and somewhat broader, their edges are separated at the base, and they are sessile; the apex is often spirally rolled; they are traversed by a stronger midrib and two to four lateral nerves, and their edges have small forwardly directed teeth, so that they agree essentially with the later foliage-leaves except in size. The intra-axillary scales are rather longer than in the case of the cotyledon.

The seedling lives at first on the nutriment stored in the cotyledon and hypocotyl; it is not for some weeks that the lateral root bores through the parenchyma on the side of the hypocotyl beneath the median line of the cotyledon. It is thread-like and unbranched.

*Stem* of the mature plant very short, stoloniferous.

*Leaves* radical, sessile, linear-lanceolate, acute, serrate with short, pungent, upwardly directed teeth, traversed by a midrib and two to four weaker parallel nerves on either side, green, glabrous, somewhat fleshy.

A submerged perennial herb.

## BURMANNIACÆ.

Benth. et Hook. *Gen. Pl.* iii. 455.

*Fruit and Seed*.—The ovary is inferior, three-celled, with axile placentation, or one-celled with three parietal placentas. Ovules minute, anatropous, very numerous on each placenta. Fruit a capsule, crowned by the marcescent perianth, terete or three-angled or three-winged, membranous; dehiscing

laterally between the ribs, or irregularly at the apex, or rarely by valves. Seeds very numerous, and very small, with a thin transparent testa, sometimes adnate to the nucleus, sometimes loose, hyaline and produced at both ends a long way beyond it. Recent researches<sup>1</sup> have shown that the seed, at any rate in many cases, contains something more than the rudimentary undifferentiated embryo which was formerly supposed to constitute the whole. Endosperm is present, and occupies the greater part of the seed, one of the cells being often very curiously developed. In *Burmannia capitata* according to Johow<sup>2</sup> a portion of the nucellus remains in the ripe seed (perisperm). In this species the number of the endosperm cells is very small (six in a longitudinal section), but they are each very large. At the apex lies, embedded in it, the undifferentiated embryo of ten cells. At the base is a small conical group of cells distinguished from the endosperm by their small size and dark colour; they are a remnant of the original nucellus and therefore perisperm. The endosperm cell at the extreme base of the embryo-sac is most curiously developed, the wall bordering on the perisperm having peculiar tap-like or coralline protuberances which penetrating the cell-contents reach almost to the opposite wall. This as well as the conical nucellar process (perisperm) may play some part in germination.

*Apteria setacea* is similar, but the differentiated endosperm-cell is hexagonal and appears symmetrically striated throughout, the protoplasm having apparently completely passed over into cellulose or a closely related substance; the perisperm is very small. The embryo, which agrees in all details with that of *Burmannia javanica* and *Gonyanthes capitata* as observed by Treub, is simpler than in *B. capitata*, containing only from three to six cells.

Burmanniaceæ is a small tropical Order of small herbaceous saprophytes containing about a dozen genera. Their germination does not seem to have been studied.

<sup>1</sup> Treub, *Extrait des Annales de Jard. Buitenzorg*, iii. pp. 120-2.

<sup>2</sup> Johow, *Pringsh. Jahrb.* xvi. (1885), p. 415.

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## ORCHIDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 460.

*Fruit and Seed.*—Ovary inferior, one-celled, with three parietal placentas, or three-celled in *Selenipedium*, *Apostasia*, and *Neuwiedia*, genera which are also markedly distinguished in other respects. Ovules anatropous, minute and very numerous. Fruit a membranous or coriaceous, cylindric, ovoid or winged capsule, rarely fleshy, and dehiscing scarcely at all or only after a time—some species of *Galeola*, *Vanilla*, and *Sobralia*, three allied genera—usually dehiscing by three or six longitudinal slits, with the valves cohering for some time or altogether at the apex or base, or finally spreading from the apex or entirely disappearing.

Seeds very numerous, minute, more or less cylindrical or spindle-shaped or tapering at one or both ends; testa thin-celled and transparent, yellow, green or brown, and very loosely enveloping the embryo. There is great variety in form, size, colour, and the configuration of the cells of the testa. Rarely is the testa winged, fitting close to the embryo from which it radiates in rows of delicate, transparent, brownish cells as in *Epistephium*, *Erythrorchis*, and *Cyrtosia*. *Vanilla* is also exceptional in having a crustaceous, dark reddish-brown, opaque testa. There is no endosperm. The embryo is in the centre or somewhat above the centre of the seed, globular, ellipsoid or ovate in shape, and represents a very low stage of development, showing before germination no trace of radicle or cotyledon. There is, however, a certain physiological differentiation, for the longer axis of the embryo corresponds to the ascending axis of the young seedling.

The seeds show a great resemblance to those of many parasites of dicotyledonous Orders, especially *Orobanche*, but most strikingly, as Beer points out, to those of species of *Pyrola*.

*Germination.*—Owing to the low stage of development of the embryo in the ripe seed, only trifling differences of form and colour occur in the most different genera and groups.

*Angræcum maculatum*,<sup>1</sup> Lindl.

*Seed* spindle-shaped with a thin transparent testa loosely enveloping the central pear-shaped homogeneous embryo.

*Germination*.—The embryo increases considerably in size and ruptures the testa from above downwards, the *débris* remaining attached at the lower end. At this stage *two* or *three* adventitious buds appear on the upper surface of the germ-tubercle; their position is very variable, and they are often all at a considerable distance from what we should imagine to be the position of the primary axis of the embryo; they all seem of the same nature, no one showing any peculiarity.

A rudimentary vascular bundle runs from the bases of the rudiments of the leaves of these buds down into the axis of the tubercle, the lower part of which, however, consists of undifferentiated cellular tissue.

The seedling is nourished by tufts of hairs which arise at numerous points of the surface of the rapidly growing top-shaped embryo. There is no trace of a primary root. The germ-tubercle has now completed its development, the future plant is produced from the adventitious buds. One of these develops more or less directly into the leaf- and flower-bearing axis, the others follow a uniform course of development and produce a branching system of tubers.

The young leaves of the bud are alternate and distichous as in the adult plant; they are reduced to minute deciduous scales, but their position can be readily ascertained by a linear scar marking their place of attachment. In the case of those which produce a secondary tubercle the bud increases considerably in bulk, the dilated axis bears distichously arranged leaf-scales in the axils of which appear buds which undergo a development similar to that of the axis on which they arose, thus producing a ramifying tuberous system. The other adventitious bud often develops for a time like its fellows, but sometimes immediately produces a leafy stem. In the former case this is developed in the axis of a leaf-scale of a secondary tubercle; in the latter the growing point of the adventitious bud itself develops into the leafy stem. The first two leaves are brownish membranous scales, the third and fourth are also scales but green, the fifth has a well-developed lamina and shows the form of a complete leaf. These primary leaves are all sheathing and at first enclosed one within the other, but they open out and extend with the growth of the axis which bears them.

<sup>1</sup> Prillieux et Rivière, *Ann. Sci. Nat. ser. iv. tom. v. (1856), p. 119, pl. 5-7.*

Up to the time when the third leaf-sheath protrudes above the summit of the second, the plant has had no organ of absorption beyond the papillæ originally developed over the whole surface of the young tubercle. But now the rudiment of a true root appears on a level with the origin of the second leaf, inside the first sheath which it tears in elongating and then bends and penetrates the soil. While it is developing the third and fourth sheaths protrude; but before the complete leaf appears, the first sheath, torn by the root, has already begun to perish.

The leaves arise but a short distance apart, the internodes being very short. When the stem grows they elongate, but very unequally; the lowest always remains the shortest, the two next do not increase very much; but the last, at the summit of which is borne the fifth leaf, grows considerably, and finally overtops the summit of the sheaths at its base. It increases in breadth and thickness as well as length, and forms the pseudo-bulb; the narrow leaf-sheaths surrounding its base become torn and perish, while it bears at its summit the only leaf which attains complete development. During the growth of the pseudo-bulb a second and third adventitious root arise in succession from the base of the third and fourth sheaths respectively; they are like the first and penetrate the ground. Henceforth the plant can live alone and draw its food from the soil. The ramified tubercle which it always bears at its base has ceased little by little to grow, and either dries up or rots. If separated from the plant when still full of life, it continues to live, and one of its buds behaves like that which originally produced the stem from which we have separated it, in fact it gives rise to a second plant. Several plants may thus be raised from the product of the germination of a single seed. The bud which develops into a stem is indifferently terminal or axillary, of the second or third order. No law apparently determines its position, but its composition is always the same: there are always five leaves, four of which reduced to sheaths surround the base of the pseudo-bulb, the highest internode. Each leaf whatever its form bears a bud in its axil. The leaves which surround the pseudo-bulb are alternate and distichous.<sup>1</sup>

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<sup>1</sup> For figures, see the original paper in *Ann. Sci. Nat.*, loc. cit. Seed and germination, pl. 5. Seedling plant and its development, p. 16, figs. 1-9.

## SCITAMINEÆ.

Benth. et Hook. *Gen. Pl.* iii. 636.

*Fruit and Seed.*—The ovary is inferior, three-celled or one-celled by arrest, two cells being small and empty as in *Maranta*, *Stromanthe*, *Ctenanthe*, *Saranthe*, *Ischnosiphon* and *Thalia*; rarely truly one-celled with three parietal placentas, as in *Mantisia*, *Globba*, *Guillainia* and *Hemiorchis*, or two-celled (*Tapeinochilus*). The ovules are solitary and erect from the base in each cell (*Heliconia*), or indefinite in one to many series on the axile, rarely parietal (*Mantisia* &c) placentas, horizontal, or ascending, anatropous. The fruit is crowned by the persistent calyx or naked, the whole perianth being deciduous, and with the seed varies considerably in the four well-marked tribes, often separated as distinct Orders, into which the Scitamineæ are divided.

## TRIBE I. ZINGIBERÆ.

The fruit where known is sometimes a loculicidally dehiscent capsule, as in *Roscoeia*, *Hedychium*, and *Costus*. The wall of the capsule is often leathery, but sometimes thin, and almost membranous, and then usually bursts irregularly as in *Globba* and *Zingiber*. In some genera (*Elettaria*, *Amomum* and *Alpinia*) it is indehiscent and almost baccate. The pericarp is usually smooth. The form of the fruit varies from round to elongated or angular, in *Burbridgea* it takes the shape of a long pod. The seeds are numerous, more or less spherical, or conical, or angular, with a rounded side towards the pericarp. The testa is smooth and shiny, grey or brownish, sometimes red, more rarely is it wrinkled on the surface. It bounds a starchy perisperm surrounding an albuminous endosperm, inside which is the embryo. The latter, however, abuts on the testa at the hilum, where the continuity of the seed-coat is interrupted by a stopper. Tschirch<sup>1</sup> has recently shown that

<sup>1</sup> Die Saugorgane der Scitamineen-Samen, in *Mitth. Math. u. Naturwiss. aus d. Sitz. der k. Preuss. Akad. der Wiss. zu Berlin*, 1890, Heft 2.

absorbent organs corresponding to the scutellum of Grass seeds and the 'suckers' of Palm seeds are present in all the tribes of Scitamineæ. In *Elettaria speciosa*, the stopper in the ripe seed is only united to the testa by a delicate ligament. The embryo consists of an elongated club-shaped sucker surrounded by the endosperm, and connected by a narrow neck with the embryo proper, which resembles a broad cone with a flat base, and includes a radicle and plumule. The portion of the testa opposite the radicle consists of a lid-like stopper, a structure which Tschirch found general in the Order. The sucker shows no differentiation, and remains in the seed in germination while the neck portion elongates, causing the stopper to be pushed out and the embryo to emerge. The radicle bends downwards and the plumule sheathed by a horn-shaped leaf, the coleoptile or cotyledon, upwards. The young seedling remains united with the internal sucker by a long filiform appendage from the base of the sheath-like cotyledon, the elongated neck of the embryo. This connection is kept up till all the reserve-material is consumed. Other species of *Elettaria*, e.g. *E. Cardamomum* as well as the genera *Amomum*, *Alpinia* and others, behave quite similarly, the differences lying in the form of the endosperm, the shape of the stopper and the sucker. In *Alpinia nutans* the latter is bilobed, grasping with one of the lobes a section of the sickle-shaped endosperm, while in *Amomum dealbatum* the similarly shaped endosperm is penetrated by a wedge-like sucker. Germination is analogous throughout.

## TRIBE II. MARANTÆÆ.

The fruit is three-celled, with one seed in each cell as in *Phrynium*, *Calathea* and others, or one-celled with one seed as in *Maranta*, *Thalia*, &c. Sometimes it is indehiscent, sometimes bursts in irregular pieces, but usually shows a valvular dehiscence, which is loculicidal in the three-seeded capsules. Where the fruit is one-seeded it may separate into three equal valves, or one valve may be small compared with the other two, sometimes linear. In *Maranta* and *Stromanthe* the valves are about equal in breadth but only one becomes separated, the other two remaining almost or quite coherent.

## TRIBE III. CANNEÆ.

The fruit is a three-celled capsule, with its surface warty or beset with weak prickles. The seeds are roundish with a straight embryo lying in the hard, very tough, white perisperm. There is no endosperm. The absorbent organ of *Canna* is club-shaped, embedded in the perisperm and separated by a plain constriction from the embryo proper. The latter consists of a sheath-like cotyledon surrounding the very well-developed plumule, in which several involute leaves can be distinguished, and a somewhat obliquely placed cone-shaped radicle forming the apex of the whole. There is no stopper in the seed-coat indicating the future point of exit of the radicle, but at the spot towards which this is directed the hard layer of palisade sclerome cells is interrupted by a sickle-shaped opening, where the testa subsequently splits.

The epidermis of the sucker consists of a layer of elongated palisade-cells. The process of germination resembles that of the Zingiberææ. The neck of the embryo elongates considerably, while the vegetative portion emerges from the testa and develops root and shoot system outside. The elongated neck-portion remains attached to the back of the cotyledonary sheath till the sucker has exhausted the nutriment contained in the perisperm.

## TRIBE IV. MUSEÆ.

The fruit is here a berry (*Musa*), sometimes fleshy as in *M. Sapientum* (the Banana), sometimes dry and almost leathery as in *M. Ensete*, or a three-celled capsule, dehiscing septicidally in *Heliconia* into three one-seeded portions, while in *Ravenala* and *Strelitzia* it is many-seeded with loculicidal dehiscence. The seed in *Musa Ensete* has a very large broad hilum, corresponding to an orbicular depression of the seed-coat. The seeds of *Strelitzia* are surrounded at the base with a bilobed woolly mantle. In *Ravenala madagascariensis* (the Travellers' tree) a sky-blue, or sometimes red, scutiform aril with fimbriated edges envelops the seed. Endosperm is absent, but a quantity of mealy, white, or yellowish-white perisperm takes

its place as a store of reserve-material. In *Musa Ensete*<sup>1</sup> the sucker has a broad disc-like shape; its epidermis is an absorbent epithelium of palisade-like cells, and in this as well as in its somewhat peripheral position with regard to the reserve-material it resembles the scutellum of Grasses. The whole bluish-green embryo is thus knob-like or rather fungoid in shape, the knob or cap being the sucker and the stalk the embryo proper terminating in the radicle. In germination the radicle elongates, pushes out the stopper in the seed-coat and emerges followed by the well-developed plumule. Connection is kept up with the sucker which remains in the seed, and increases considerably in size until the perisperm is exhausted and the seedling by developing green leaves has become independent.

## BROMELIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 657.

*Fruit and Seed.*—The three-celled ovary is inferior in the tribe Bromeliæ, half inferior in the Pitcairniæ, and superior in the Puyæ and Tillandsiæ. The ovules are anatropous and usually very numerous when the fruit becomes capsular, or few when a berry is produced. The curvature is mostly towards the free side, the ovules in the upper part of the ovary being turned upwards (epitropous), those near the base downwards (apotropous), the rest usually apotropous, or turned sideways (pleurotropous). The placentas are often provided with palisade-like mucilage-cells (*Æchmea*, *Portea*), and this obtains more or less in all genera with pulpy berries. As in many Monocotyledons, we find in the dividing walls of the ovary-cells, clefts lined with honey-secreting cells, the so-called septal glands.

The fruit is baccate in the Bromeliæ where the ovary is inferior, sometimes almost leathery (*Æchmea*, *Billbergia*), in the other tribes it is a capsule. In *Ananas* (the Pineapple), the axis, bracts and fruits are all fleshy and united into a

<sup>1</sup> Wittmack, '*Musa Ensete*,' *Linnaea*, 85, taf. iii.

pseudocarp; the axis is proliferous, growing through and forming at the apex of the whole a tuft of green leaves. The berry is sometimes of a brilliant colour, e.g. red in *Lamprococcus fulgens*, blue in the monotypic genus *Ronnbergia*. There is considerable variety in size and shape; the berry may be globose or cylindrical, the size of a small pea, or several inches long. The capsule dehisces septicidally by three valves separating from the apex downwards.

The seeds are usually numerous, fewer where the fruit is baccate, and then usually ovate or lenticular (*Bromelia*, *Billbergia*), in capsular fruits lenticular (*Dyckia*), elongated (*Pitcairnia*), or linear (*Tillandsiæ*). The seed-coat is often provided with means of distribution, such as an asymmetrical wing (*Dyckia*), tuft-like appendages at the apex or both ends (*Pitcairnia*), or silky hairs as in the *Tillandsiæ*. These structures usually arise from the outer integument, the hairs also from the funicle.

The seeds contain a large quantity of endosperm, the embryo being small and excentric; sometimes as in *Bromelia* embedded in the endosperm, but more often lateral as in Grass seeds (cf. *Dyckia*, *Caraguata*, *Guzmannia*). The embryo consists of a radicle, with a frequently well-developed hypocotyl bearing a single cotyledon which sheathes the plumule, while the absorbent organ present in the albuminous *Scitamineæ* is according to Tschirch developed in *Bromeliaceæ* in a relatively great variety of ways.<sup>1</sup> Sometimes, as in *Caraguata*, it forms a structure resembling the scutellum of Grasses, sometimes it is club-shaped, penetrating deeply into the endosperm, as in *Guzmannia*.

The species of this Order being mostly epiphytes growing on trees, and inhabiting the tropical and subtropical parts of America, their germination has not been much studied.

According to Klebs,<sup>2</sup> germination takes place in *Acanthostachys strobilacea* in a manner common to a great number of Monocotyledons. The primary root projects first and grows rapidly downwards, provided in this case, except at the apex, with a thick covering of long hairs. One end of the

<sup>1</sup> *Loc. cit.* p. 94.

<sup>2</sup> *Beiträge zur Morphologie u. Biologie der Keimung*, p. 565, fig. 11.



cotyledon remains in the seed, forming the absorbent organ; the other emerges and forms a short sheath. The second leaf emerges from the top of this sheath.

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## IRIDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 681.

*Fruit and Seed.*—The ovary is inferior and three-celled with axile placentas, or very rarely, as in *Hermodactylus*, one-celled with three parietal placentas. The ovules are usually numerous in each cell, rarely reduced to one or two; they are anatropous. The fruit is a globose, obovoid, oblong or rarely linear capsule, with a loculicidal dehiscence. Sometimes, as in *Tigridia*, *Rigidella*, and *Herbertia*, the top protrudes beyond the perianth-tube, leaving a free operculum at the bottom of which the dehiscence stops at any rate for a time. The seeds are few or numerous, superposed in two series, rarely solitary in each cell with short, often very short funicles, and a strophiole. They vary much in shape, and may be globose or generally angular by mutual pressure, but sometimes flattened. Variations occur even in the same genus, thus *Gladiolus segetum* has globose seeds, while in the very closely allied *G. byzantinus* they are flat. The testa is membranous or slightly thickened and spongy. The endosperm is horny and fills the seed. The small embryo is completely enclosed in the endosperm at a little distance from the hilum.

*Germination.*—We may distinguish three types characterised by differences in form and behaviour of the cotyledon. The first, according to Klebs,<sup>1</sup> is represented by *Iris Pseudacorus* and *Ixia crateroides*. Here, as in the two following types, the primary root is the first to emerge from the seedling, and grows rapidly downwards. The hypocotyl is very slightly developed, but the lower end of the cotyledon elongates at an early period of germination drawing out of the seed the plumule which is enclosed in its sheathing base. The

<sup>1</sup> *Loc. cit.* pp. 564–5, fig. 11.

other end remains in the seed. The cotyledon thus consists of a short lower sheathing portion, from which the second leaf soon breaks in the form of a long, slender, wedge-like sheath with a green tip, and an upper portion perfectly continuous with it in connection with the seed, its apex remaining embedded in the endosperm. This is the simplest type. We have represented, in what is evidently a single structure, the cotyledon, first an absorbent organ to absorb the endosperm contained in the seed ; secondly a means of connection between this and the seedling ; and thirdly a protecting sheath for the developing plumule.

In the second type, the more general one in the Order, the cotyledon shows greater differentiation of structure, the parts which perform the three functions being quite distinct from each other. The lower portion still forms the protecting sheath, but is much longer than in the first type. Attached to it, either at the apex, or some varying distance below, is a long thread-like connective, the other end of which is swollen into a more or less club-shaped absorbent organ, buried in the endosperm of the seed. As in the first type the whole of the cotyledon remains beneath the ground. This obtains, according to Irmisch, in *Iris sibirica* and *I. Xiphion*,<sup>1</sup> and probably in many other species, also in *Gladiolus communis*, *palustris*, and other species. Alefeld<sup>2</sup> says a *Moræa* germinated just like *Iris*.

The third type differs in that the long thread-like cotyledon after exhausting the endosperm gets quite free from the seed and appears above the soil as the first green foliage-leaf. Hence the striking differentiation of structure of the last type is absent. The hypocotyl, as general in the Order, is undeveloped. Germination begins with the elongation of the lower part of the cotyledon, which pushes the root before it, and follows it, both growing quickly, a short distance downwards in the soil. Rapid growth at the bend causes the cotyledon to form a sharp knee, and each of the two limbs continuing to grow, this is pushed upwards, thus breaking the soil in the manner of the hypocotyl of many Dicotyledons.

<sup>1</sup> *Abhandl. Nat. Ver. Sachs. u. Thuring. Halle*, i. p. 139.

<sup>2</sup> Alefeld, *Bot. Zeit.*, 1864, p. 246.

When the endosperm is exhausted it draws itself quite out of the withering seed, the bend becomes straightened, and the whole cotyledon then appears above the soil as the first green foliage-leaf. From its sheathing base appears the second. This method occurs in *Sisyrinchium*. Velenovsky<sup>1</sup> describes the same in seedlings of *Iris* sp.

***Gladiolus communis*, L.**

*Primary root* tapering downwards, branching slightly.

*Hypocotyl* undeveloped.

*Cotyledon* subterranean, of three parts, an absorbent organ remaining in the seed, connected by a long thread-like part with the top of the sheath, the lower end of which is continuous with the base of the root. The latter portion forms a long sheathing tube, cleft on the ventral side, with a rounded, somewhat truncated apex to the back of which the connective is attached.

*The first foliage leaf* emerges from the sheath. It is broad and compressed, and its long, narrowly cleft sheath includes the following leaf. During the first vegetative period the internode between the insertion of the first foliage-leaf and that of the sheathing-leaf which follows it and encloses next year's leaf-structure, swells to a tuber. This is at first covered by the thin sheath of the cotyledon (the connective has long since died away), but this soon perishes, and the tuber is protected by a dry envelope formed from the sheath of the succeeding foliage-leaf. The terminal bud by which the plant will resume growth next season occupies the apex of the tuber. The primary root perishes towards the close of the first period, a few fleshy adventitious roots break out, close to it, from the short axis beneath the tuber, but as these are often wanting they do not appear to be essential for the nourishment of the plant. Up to time of flowering the plants, which, save for increase in size and number of the leaf-structures, do not alter essentially in the next year, continue to grow by means of the terminal bud, while axillary buds also appear.

The leaves of the adult plant are long, ensiform, sheathing at the base, lanceolate, acute, and entire with several prominent nerves.

<sup>1</sup> *Flora*, 1887, p. 454.

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## AMARYLLIDÆ.

Benth. et Hook. *Gen. Pl.* iii. 711.

*Fruit and Seed.*—The ovary is inferior and three-celled with axile placentation, very rarely one-celled with parietal placentas. The ovules are numerous in each cell and superposed in two ranks, rarely reduced to one or two, and always anatropous. The fruit is capsular or succulent, undivided or trilobed, variously dehiscent or indehiscent. The seeds are globose, or angled, or flattened by mutual pressure, and have a membranous or thickened, often black testa. Endosperm is copious and fleshy or rarely horny. The embryo is small, rarely half as long as the endosperm. Important exceptions to the above characters occur in *Calostemma* which has by abortion a one-celled ovary with one or two ovules, and in *Leontochir* which has a triangular, one-celled ovary with three parietal placentas.

The fruit of *Crinum* is capsular and irregularly subglobose according to the number of seeds it contains. The seeds are very large and irregularly compressed with a thick testa. In some cases at least they commence to germinate soon after they are mature and have dropped on the ground, or even when kept in a drawer or other dry place. This they are able to do by reason of the large quantity of endosperm and the moisture they contain. The seeds in the capsule of *Nerine* are few or solitary and greenish. The capsule generally if not always bursts open, exposing the seeds long before they are ripe; after thus dehiscing the valves do not seem to increase in size.

*Seedlings.*—The solitary cotyledon is frequently subterranean, and in other cases where it rises above ground, it carries up the seed with it as shown by *Agave Wislizeni* (fig. 680). The hypocotyl in this case is undeveloped, the primary root is stout and fleshy, and adventitious roots are soon given off close to the base of the cotyledon.

The latter is subulate, elongated, dilated and sheathing

at the base, and 3·3–6 cm. long. The first leaf emerges from the sheath of the cotyledon, is sessile, lanceolate, acuminate, and minutely spiny at the margin.

*Agave Wislizeni*, Engelm. (fig. 680).

*Primary root* stout, tapering downwards, colourless, soon giving off adventitious roots close to the base of the cotyledon.

*Hypocotyl* undeveloped.

*Cotyledon* succulent, subulate, elongated, much tapered to the apex, and carrying up with it the rotund-ovate, thin and much compressed black testa, much dilated and sheathing at the base, above which it is split to allow the plumule to emerge, terete, glabrous, deep green, 3·3–6 cm. long, 2·5–3 mm. in diameter above the basal sheath.

*Stem* succulent, very short, with undeveloped internodes, except in the flowering stem.

*Leaves* simple, radical, alternate, exstipulate, sessile, succulent, glabrous, deep glaucous-green on both surfaces, concave in veneration or convolute, spiny at the margin at least in the seedling stage, without discernible venation.

No. 1. Lanceolate, acuminate, deep glaucous-green with a hyaline minutely spiny margin, emerging from the basal sheath of the cotyledon.

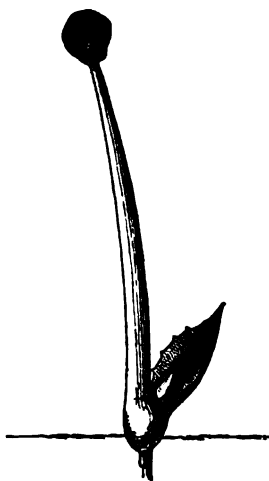


FIG. 680.—*Agave Wislizeni*.  
Nat. size.

## DIOSCOREACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 741.

*Fruit and Seed*.—The plants of this Order have monœcious or diœcious and only exceptionally or abnormally hermaphrodite flowers. The ovary is inferior, and three-celled with axile placentation and two ovules in each cavity, suspended from near the apex of the placentas and anatropous or almost

amphitropous. The fruit is capsular and three-valved or baccate and indehiscent; when capsular the seeds are compressed, and when baccate they are globose. In both cases these forms relate to the method of distribution. The endo-

sperm is fleshy or almost cartilaginous. The embryo is small and slightly distant from the hilum.

The seed of *Testudinaria elephantipes* is elliptic, very much compressed or flattened, and winged.

*Seedling.* — *Testudinaria elephantipes* (fig. 681) may be given as a type of the Order. The cotyledon remains in the seed after germination till it decays. The hypocotyl is subterranean, very short, and develops in the early stages of the seedling into an ovoid, fleshy tuber. The first leaf is comparatively large, cordate and somewhat reticulate with five strong nerves radiating from the base, and becoming curved at their tips. The persistent root-stock or stem ultimately becomes a woody, flattened, globose or conical mass, rather deeply fissured in a

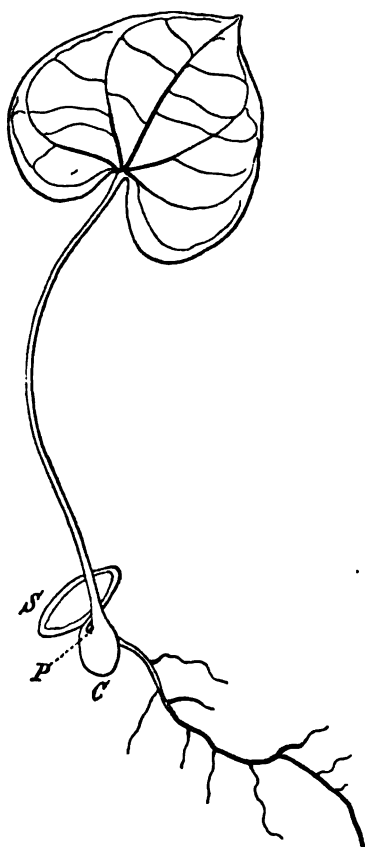


FIG. 681.—*Testudinaria elephantipes*.  
S, seed; P, plumule; C, fleshy tuber from  
hypocotyl. Nat. size.

reticulate manner, presenting the appearance of the shell of a tortoise.

*Testudinaria elephantipes*, Burch. (fig. 681).

*Primary root* elongated, flexuose, stout, with fibrous lateral rootlets.

*Hypocotyl* very short, subterranean, thickening into a fleshy,

ovate tuber, generally if not always rootless during the earlier stages of growth.

*Cotyledon* subterranean, remaining in the seed and fusing with or closely adhering to the endosperm, where it remains till decay.

*Stem* undeveloped in the early stages of the seedling.

*Leaves* simple, entire, radical or cauline, alternate, exstipulate, petiolate, glabrous, reticulated, with the principal nerves radiating from the base and becoming incurved upwards.

No. 1. Cordate, subacutely cuspidate, with five strong leading nerves radiating from the base, and two weaker branches from the basal pair.

## LILIACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 748.

*Fruit and Seed.*—The ovary is superior and generally three-celled, with axile placentation, sometimes one-celled with three parietal placentas, very rarely two- to four- to many-celled. The ovules are twin in each cell and collateral or numerous and arranged in a double series, rarely solitary; they are anatropous, semianatropous, or in some genera orthotropous. The fruit is baccate and indehiscent, or capsular; in some cases the three component carpels are separated almost to the base. The seeds vary, being flattened, angular or globose, and with or without an ariloid. The testa also varies in thickness and texture, and is sometimes developed into a wing. Endosperm is plentiful and fleshy, cartilaginous or horny. The embryo is very small and globular, or elongated and straight or curved, with the radicle close to the hilum, or sometimes distant from it. The ovules are exceptional in *Smilax*, *Ruscus*, and some of their allies in being orthotropous.

Instances of globose or subglobose seeds are met with in *Ruscus*, *Asparagus*, *Polygonatum*, *Convallaria*, *Hyacinthus*, and others. The seeds of *Tulipa*, *Lilium*, *Fritillaria*, *Urginea* and others are flattened or much compressed. Angular seeds are met with in *Allium*, *Galtonia*, *Paradisica*, *Asphodelus*, *Asphodeline*, *Anthericum*, and others.

*Seedlings.*—The cotyledon in this Order is generally, if

not always, aerial, and carries the seed up with it during germination. The testa is ultimately dropped, generally by the decay of the tip of the cotyledon. The hypocotyl of *Bowiea volubilis* (fig. 682) is undeveloped; and the primary root soon superseded by fleshy, adventitious roots. The cotyledon is terete and solid except at the base, which is hollow and sheaths the plumule; it becomes very much inflated there, constituting the first tunic of the bulb. It varies greatly in length, from 10–23 cm. in different seedlings. The first leaf resembles the cotyledon except in being very much shorter. The leaves of the adult plant arise from the bulb and are deciduous; those of the much branched and twining flower stem are reduced to bracts. On small bulbs the radical leaf is solitary, semi-terete, and channelled on the upper surface.



FIG. 682.  
*Bowiea*  
*volubilis*.  
Half nat. size.

The primary root of a species of *Tulipa* (fig. 683) from Afghanistan is short, fleshy, unbranched, and soon dies away. The hypocotyl is undeveloped, and the cotyledon is terete, thickest in the middle, tapering each way, and carries the testa for a time at its apex. It soon becomes gibbous at the base, and then develops into a blunt tube which penetrates the soil, carrying the plumule down with it at the bottom of the tube, and both together constitute the first bulb. The object of this peculiar growth is to bury the bulb at a sufficient depth in the soil. The process is repeated in succeeding years when fresh growth is being made, in order to carry it still further beneath the soil as it gains strength. No true leaves are developed during the first year of the plant from seed.

*Bowiea volubilis*, Harv. (fig. 682).

*Primary root* tapering downwards, transversely wrinkled flexuose, with flexuose lateral rootlets, soon superseded by long fleshy, colourless and, at least in the early stages, unbranched adventitious roots.



*Hypocotyl* undeveloped.

*Cotyledon* erect, terete, solid, dilated at the base forming the first bulb, including the plumule, tapering gradually upwards to a slender point, bearing the small black shining obovoid testa, which it retains until the tip withers and allows the testa to fall off, glabrous, deep shining green, dotted with minute colourless points, 10–23 cm. long, 1.5–2.5 mm. thick.

*Stem* excessively short in the seedling stage, with undeveloped internodes, ultimately producing a bulb 10–15 cm. or more in diameter. Bulb of cotyledon 4.5–6 mm. in diameter. The old bulb consists of a few closely adpressed, green and fleshy tunics or sheaths.

*Leaves* simple, entire, radical and cauline, alternate, exstipulate, sessile, glabrous, soon falling away or deciduous.

No. 1. Radical, erect, terete, bright green, pushed out from the base of the cotyledon, and similar to it, 1.8 cm. or more long. Leaves of the flowering stem numerous, small and scale-like, subtending the numerous branches and branchlets.

*Tulipa* sp. (fig. 688).

*Seed* obovate, very much flattened vertically, thin, winged, glabrous, brown, with a very small micropyle even after germination and not splitting, 8–9 mm. long, 6.5–7.5 mm. wide.

*Primary root* fleshy or succulent, brittle, rather thick and tapering very little, apparently never branching, and soon dying away, straight or flexuose, whitish or dirty yellow, with few or no root-hairs.

*Hypocotyl* undeveloped.

*Cotyledon* terete, solid, elongated, thickest in the middle and tapering to the base, but more so to the apex, which is produced into a very slender point usually carrying the testa; deep subglaucous-green, glabrous, withering early at the tip, allowing the testa to drop, 7–8.5 cm. long; basal part becoming gibbous and hollow, forming a very blunt point which pushes its way downwards into the soil carrying with it the plumule, and finally ending in a blunt point with a few undeveloped root-like

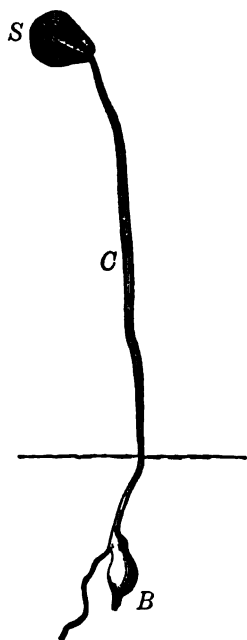


FIG. 688.—*Tulipa* sp. Nat. size. S, seed; C, cotyledon; B, primary bulb.

protuberances ; above this it swells, forming the first bulb, a small ovoid body containing a fleshy scale-leaf.

*Leaves* none the first year.

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## PALMÆ.

Benth. et Hook. *Gen. Pl.* iii. 870.

*Fruit and Seed.*—The ovary is free, ovoid, oblong or globose, rudimentary or absent in male flowers, more or less perfectly three- rarely four- to seven-celled, entire or trilobed, or formed of three more or less distinct carpels. The ovules are solitary in each carpel and erect or fixed by a broad base to the interior angle, subhorizontal or pendulous, anatropous or semi-anatropous. Fruit dry, baccate or drupaceous, with the terminal excentric, lateral or basilar remains of the style or stigmas, one- rarely two- to many-celled and -seeded, rarely consisting of one to three distinct one-seeded carpels. Exocarp frequently fibrous, endocarp membranous, crustaceous, woody or stony, smooth internally or wrinkled and marked by the branching raphe, having in the *Cocoinæ* three symmetrical pits, two of which correspond to barren cells. Seeds conforming to the endocarp, and free or adherent to it, with a basilar or lateral hilum ; testa closely adherent to the albumen, raphe short or elongated, often adherent to the endocarp, sometimes surrounding the seed with numerous branches varying in direction and often branching again or reticulate. Endosperm horny or cartilaginous, sometimes oily, solid or hollow or indented at the apex or side, often ruminant. Embryo small, conical or cylindrical, sunk in the periphery of the endosperm, usually at the hilum next the dorsal side, rarely lateral or apical.

*Germination* takes place according to a very prevalent monocotyledonous type. The radicle, pushing aside the operculum in the testa, emerges first, and penetrates the soil usually to a considerable depth, becoming both long and strong. The very short hypocotyl is thus drawn out of the seed, bearing the rapidly elongating sheath of the cotyledon

which encloses the plumule. The other end of the cotyledon remains in the seed, forming a sucker to absorb the endosperm; a narrow neck connects it with the sheath portion, from which the first green leaf soon protrudes.

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## AROIDEÆ.

Benth. et Hook. *Gen. Pl.* iii. 955.

*Fruit and Seed.*—The ovaries are superior and numerous on each inflorescence, globose, ovoid, oblong or flask-shaped, one- to many-celled, and arranged spirally on a fleshy axis or spadix, or in parallel and longitudinal rows in the case of *Spathicarpa* and *Spathanthemum*. The ovules are solitary or several in each cell, basal, parietal, axile or inserted on the edges of half-intruded septa, or pendulous from the apex of the cell and orthotropous, anatropous, or half-anatropous, rarely campylotropous or amphitropous. The fruit is baccate or membranous, indehiscent or dehiscing tardily. The seeds are small or large with a variable testa and a copious, fleshy, rarely farinaceous endosperm, or may be scanty and sometimes absent. The embryo is elongated, rarely small, and horseshoe-shaped where endosperm is absent.

*Seedling.*—In *Anthurium margaritaceum* the cotyledon is subterranean, with an extremely short petiole or none at all, and remains in the seed till it decays. The primary root is soon superseded by strong adventitious roots from the stem at the base of the leaves. The hypocotyl is undeveloped; and the first internode of the stem is 5 mm. long, but subterranean. The first three leaves are ovate-elliptic and trinerved.

### *Anthurium margaritaceum*, Baker.

*Seeds* small, 2 mm. long by 1.25 mm. wide.

*Primary root* soon superseded by long and fleshy adventitious roots.

*Cotyledon* subterranean, remaining in the seed till it decays.

*Stem* exceedingly short, inconspicuous, pale green or colourless, glabrous, extending 5 mm. below ground.

*Leaves* simple, entire, radical, alternate with very short internodes, acute, ovate-elliptic, glabrous, bright green, with petioles slightly longer than the leaf, exstipulate; midrib and two lateral nerves meeting at the apex with subsidiary veins between given off from the midrib.

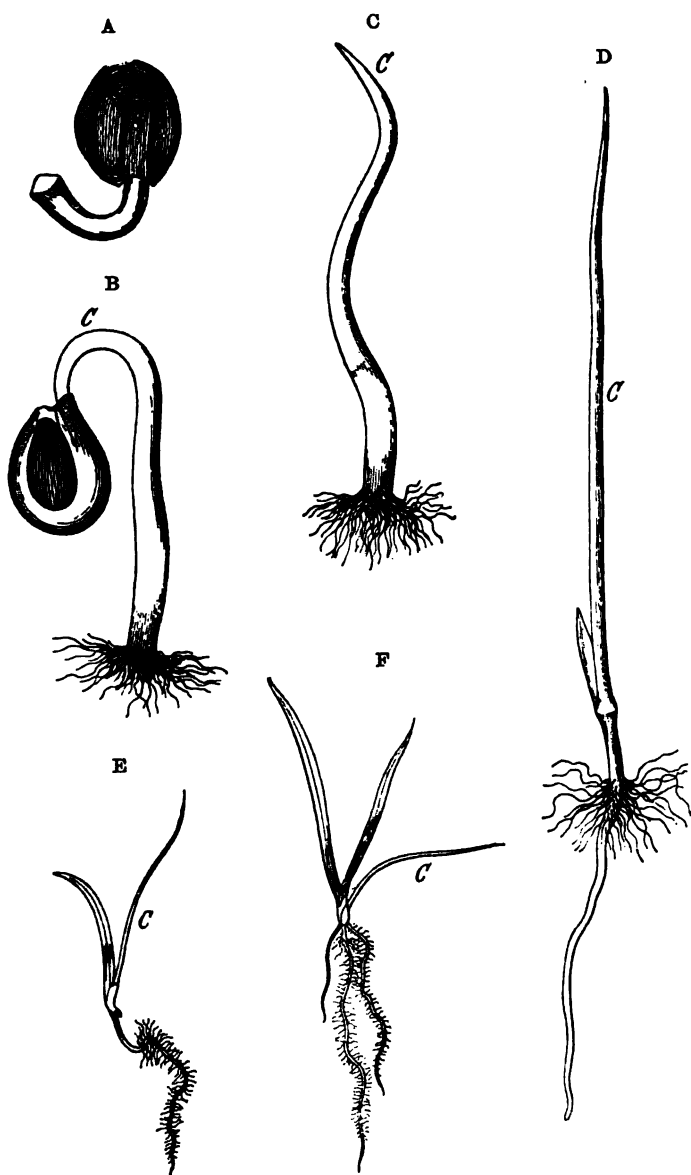
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## ALISMACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 1003.

*Fruit and Seed.*—The ovary consists of six free carpels, or more rarely three, arranged in one or many series on the receptacle; sometimes they are connate at the base and one-celled. The ovules are solitary in each cell, or twin and superposed, or numerous and inserted on the interior angle; very seldom are they solitary and basal; in the tribe Butomeæ they are very numerous and inserted on reticulately branched placentas all over the walls. They vary greatly in being anatropous, half-anatropous, amphitropous, or campylotropous with an inferior micropyle. The fruit consists of free carpels, or they are united at the base and dehiscent at the ventral suture or indehiscent, very seldom circumscissile at the base. The seeds are ovoid, oblong, or compressed, small or minute, and exalbuminous with a variable testa. The embryo is conduplicately horseshoe-shaped, often thickened at the radicle, very rarely straight, with the plumule hidden at the base of the cotyledon.

*Seedling.*—Owing to the absence of endosperm in the seeds, the cotyledon in this Order is probably always aerial or aquatic. *Alisma Plantago* (fig. 684) may be given as a type. The peculiarly thickened hypocotyl so frequent in the Order is noticeable even from the first stages of germination. It produces numerous root-hairs from the edge of the thickened extremity, fixing the seedling in the soil or mud. The radicle itself does not begin to elongate till five or six days after germination. It is devoid of root-hairs for some time, but twelve days after germination they are copious. Adventitious roots commence to be given off from the first node about this time. The cotyledon is subulate-linear or filiform, and sheathes

FIG. 684.—*Alisma Plantago*.

A, B, and C,  $\times 8$ : D,  $\times 4$ : E, nat. size: F, nat. size: C, cotyledon

the plumule by its base. The first two leaves are linear, acuminate, one-nerved and Grass-like. The ultimate ones are oblong-elliptic and comparatively broad.

The primary leaves are often, if not always, relatively very narrow, and the ultimate ones in several genera are broad, oblong, elliptic, oval or sagittate. Those of *Sagittaria montevidensis* are sometimes eighteen to twenty-four inches wide and proportionately long.

### ***Alisma Plantago, L.***

#### *Germination* (fig. 684).

Seeds sown in a greenhouse, in soil sunk in water, germinated in three days.

The carpels are cuneate, or rather like the segments of an orange, and the seed lies in the interior so that the radicle of the curved embryo occupies the outer and thicker part of the carpel. The radicle being much the thicker part of the embryo requires this accommodation.

The hypocotyl first emerges, and ends very bluntly or even truncately with a thickened margin around the tip (fig. 684, A).

Three days after germination (fig. 684, B) the thickened margin at the base of the hypocotyl gives out numerous root-hairs which fix the plantlet in the soil. The place from whence the plumule should emerge is dimly visible at the base of the slender cotyledon. The carpel or achene is now suspended at the tip of the cotyledon. Hypocotyl very short. Neither the radicle nor the lateral adventitious roots are yet visible.

Four days after germination (fig. 684, C) the cotyledon rises up, freed from the achene, but is still slightly twisted at the end.

Seven days after germination (fig. 684, D) the cotyledon becomes much elongated, narrowly subulate or filiform, tapering slightly upwards and straight. The root-hairs are still copious at the base of the short hypocotyl, and the primary root has become considerably elongated. The plumule is also considerably advanced.

Twelve days after germination (fig. 684, E) the cotyledon has not altered. First leaf linear, acuminate, thin, membranous, showing a distinct midrib. An adventitious rootlet is seen just pushing from the first node, above the hypocotyl. Primary root elongated and furnished with root-hairs nearly to the tip.

Nineteen days after germination (fig. 684, F) the cotyledon is still unaltered. First and second leaves linear, acuminate, with a distinct

midrib, sheathed at the base by the cotyledon. Primary root elongated and furnished with root-hairs. Adventitious roots also from the first node well furnished with root-hairs.

## CYPERACEÆ.

Benth. et Hook. *Gen. Pl.* iii. 1037.

*Fruit and Seed.*—The ovary is entire, erect and sessile in the centre of the flower, or sometimes placed on a short stalk which may be thickened or expanded to form a disc. It is one-celled and contains a solitary anatropous ovule, erect from the base. The fruit is small, covered by the glume or protruded beyond it, nut-like and indehiscent; when the style is bifid, it is more or less flattened or biconvex, and with a trifid style obscurely or distinctly trigonous. The pericarp is crustaceous and hardened or sometimes subdrupaceous, the exocarp thin or suberously thickened, the endocarp hard. The seed is erect from the base of the fruit, free (? always) from the pericarp, and has a thin testa. The small embryo is lenticular, globose or ovoid and situated within the base of the copious farinaceous or fleshy endosperm.

*Seedling.*—Poiteau<sup>1</sup> in 1808 recognised that the germination of the Cyperaceæ differed from that of Gramineæ, resembling that of Palms and Liliaceæ, while Klebs in his recent memoir<sup>2</sup> separates it as a distinct monocotyledonous type. Unlike that of Grasses, the germination in this Order has been little investigated. Mirbel<sup>3</sup> describes and figures that of *Carex maxima*, and Richard<sup>4</sup> that of *Scirpus supinus*; but beyond this we have little information on the subject till Klebs' memoir.

According to the last author the process is very uniform in the different genera and species investigated (*Scirpus lacustris*,

<sup>1</sup> *Ann. Mus. d'Hist. Nat.* xiii. Paris, 1809.

<sup>2</sup> 'Beiträge zur Morphologie u. Biologie der Keimung,' in Pfeffer's *Untersuch. aus d. Bot. Inst. Tübingen*, i. p. 571.

<sup>3</sup> *Ann. Mus. d'Hist. Nat.* xvi. p. 437 (Pl. i.) Paris, 1810.

<sup>4</sup> *Ibid.* xvii. pp. 228-9 (Pl. v. fig. 17). Paris, 1811.

*Cyperus Iria*, *C. Papyrus*, *Isolepis Savii*, *Carex caucasica*, *C. lagopina*, and *Kobresia caricina*). He points out that the structure of the embryo is somewhat different from that of the Grass-embryo, connecting the latter with the typical liliaceous type. The lower end is always occupied by the radicle without any marked root-sheath, the upper by the cotyledon. The Cyperaceæ agree with the Grasses in the distinct development of the cotyledonary sheath, which encloses the clearly indicated first leaf. In germination the cotyledon alone at first grows. The sheath elongates, breaks through its coverings, and bends geotropically upwards.<sup>1</sup> The middle portion of the cotyledon then grows rapidly, and pulls the main root out of the seed. Before the appearance of the root, a circle of long hairs is developed at the base of the cotyledonary sheath, probably on the portion corresponding to the hypocotyl which does not develop. The hairs take the place of the root in the early stages. The primary root gradually develops while the first leaf appears from the sheath. Ultimately the primary root elongates considerably, the first adventitious root breaks from the base of the cotyledonary sheath, and other leaves succeed the first. The end of the cotyledon which remains in the seed swells until, after absorbing all the endosperm, it almost fills the interior.

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## GRAMINEÆ.

Benth. et Hook. *Gen. Pl.* iii. 1074.

*Fruit and Seed.*—The ovary is sessile or shortly stalked, erect, entire or sub-bidentate at the foot of the styles. It is one-celled and contains one ascending anatropous ovule, fixed near the base or laterally, and often separable with difficulty from the ovary. The fruit is termed a caryopsis, and is indehiscent, usually small, and included in the glume and pale with a fragment of the rhachilla, together with which or the whole

<sup>1</sup> Well shown by Mirbel in *Scirpus romanus* in *Éléments de Physiologie Végétale*, p. 59, fig. 4.



spikelet it drops off; it rarely protrudes from the glume or falls separately. The pericarp is usually very thin, closely adnate to the seed with a mark over the hilum, rarely loose, membranous, or in some members of the tribe *Bambuseæ*, hard and crustaceous or very thick and fleshy. The seed-coat is adnate to, and not to be distinguished from the pericarp, or is free from the latter and very thin and adnate to the endosperm. The endosperm is copious, and farinaceous or rarely fleshy. The embryo is small, globose or depressed, often minute and situated at the base of the endosperm. It shows a very characteristic distinction of parts, and often a high development. The most characteristic is the cotyledon, which consists of two clearly separated portions: the *scutellum* or absorbent organ which remains in the seed in germination, first causing the solution of the nutrient endosperm and then absorbing it; and the sheathing portion which protects the plumule and in germination penetrates the soil and appears above the earth still enveloping the first green leaf. This view of the morphology of the cotyledon was hinted at by Gaertner<sup>1</sup> and subsequently elaborated and strongly insisted on by Van Tieghem<sup>2</sup> from the anatomy of the organs especially the course of the vascular bundles. A similar arrangement has lately been described by Tschirch in the *Scitamineæ* (see *ante*, p. 566). The radicle is enclosed in the root-sheath (*coleorhiza*); several lateral rootlets are often indicated.

*Seedling*.—The germination of Grasses has been carefully investigated by many workers from Mirbel, Poiteau and Richard onwards. It differs from that of *Cyperaceæ* by the radicle, and not the cotyledon, first emerging and growing rapidly downwards. The root-sheath is first slightly protruded from the seed, but is soon broken by the root which rapidly elongates, and is usually closely covered with hairs, which are also often found on the free surface of the root-sheath. The cotyledonary sheath grows upwards, penetrates the testa, pericarp, and the glume when present, and makes its way through the soil as a sharp wedge, while the scutellum slowly absorbs the endo-

<sup>1</sup> *De Fructibus*, &c. 1788, i. p. cxlix.

<sup>2</sup> 'Observations anatomiques sur le Cotylédon des Graminées,' *Ann. Sci. Nat.* ser. v. tom. xv. (1892), p. 236.

sperm. In some cases, as in *Sorghum*, *Panicum*, and *Eleusine*, intercalary growth occurs in the tissue (? hypocotyledonary) at the base of the sheath separating it by a narrow limb from the scutellum.

Growth of the primary root is always limited ; sooner or later numerous adventitious roots break through and take its place.

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## CAPRIFOLIACEÆ.

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## CARYOPHYLLACEÆ.

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## COMPOSITÆ.

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## PHILYDRACEÆ.

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## PHYTOLACCACEÆ.

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